

VOLUME III – TECHNICAL SPECIFICATION AND APPROVED MAKES LIST**TIDEL PARK LIMITED**

E-TENDER FOR Construction of IT Office Building, Ground Floor + 12 Floors + Terrace, Including Civil Construction, Interior Finishing Works, MEP Works and Other Allied Development Works at Mattuthavani in Madurai.



Bidder's Stamp & Initials

TIDEL PARK LIMITED
NATIONAL COMPETITIVE E-TENDER
E-TENDER FOR Construction of IT Office Building, Ground Floor + 12 Floors + Terrace, Including Civil Construction, Interior Finishing Works, MEP Works and Other Allied Development Works at Mattuthavani in Madurai.
VOLUME – III
TECHNICAL SPECIFICATION AND APPROVED MAKES LIST
DUE DATE FOR SUBMISSION: ON OR BEFORE: 07-09-2024 at 3:00 PM
URL for online bid submission for e-tender: https://www.tntenders.gov.in/
TENDER SUBMITTED BY: M/s. _____ Address: _____
AUGUST 2024

CONTENTS		
S.No	DESCRIPTION	No of Pages
1	TECHNICAL SPECIFICATIONS FOR CIVIL AND ARCHITECTURAL WORKS	138
2	TECHNICAL SPECIFICATIONS FOR LANDSCAPE WORKS	
	i. HARDSCAPE WORKS	6
	ii. SOFTSCAPE WORKS	11
3	TECHNICAL SPECIFICATIONS FOR FACADE WORKS	92
4	i. TECHNICAL SPECIFICATIONS FOR ELECTRICAL WORKS	203
	ii. DATA SHEET FOR ELECTRICAL WORKS	36
5	i. TECHNICAL SPECIFICATION FOR HEATING VENTILATION AND AIR CONDITIONING SYSTEMS	233
	ii. DATA SHEET FOR HVAC WORKS	13
6	TECHNICAL SPECIFICATIONS FOR FIRE PROTECTION SYSTEM WORKS	69
7	TECHNICAL SPECIFICATIONS FOR PLUMBING SYSTEM WORKS	101
8	TECHNICAL SPECIFICATIONS FOR SEWAGE TREATMENT PLANT	237
9	TECHNICAL SPECIFICATIONS FOR SOLID WASTE MANAGEMENT SYSTEM	13
10	TECHNICAL SPECIFICATIONS FOR ELV SYSTEM	271
11	TECHNICAL SPECIFICATIONS FOR WATER (DOMESTICE & RECYCLED) SUPPLY SYSTEM	47
12	TECHNICAL SPECIFICATIONS FOR SEWERAGE WORKS	19
13	LEED GUIDELINES	38
14	EXTRACT OF SOIL REPORT	16
15	APPROVED MAKES LIST	-

TECHNICAL SPECIFICATIONS CIVIL WORKS

CONTENTS

1.	EARTHWORK IN GRADING, EXCAVATION AND BACK FILLING	5
2	DEWATERING	16
3	REINFORCED CONCRETE AND ALLIED WORKS	17
4	TERMITE PRECONSTRUCTIONAL CHEMICAL TREATMENT IN BUILDINGS.....	45
5	STRUCTURAL STEEL WORKS	49
6	MORTARS	69
7	BLOCK MASONRY WORKS	81
8	PLASTERING.....	88
9	PAINTING	95
10	FLOOR FINISHES	109
11	FALSE CEILING	117
12	SHUTTERS AND DOORS	119
13	CAVITY / FALSE FLOOR	135

TECHNICAL SPECIFICATIONS - CIVIL WORKS**1. Order of Precedence of Specifications**

The order of precedence in referring to various specification are as follows in ascending order

- a. Technical specification of the Contract
- b. Indian Standard specifications
- c. PWD of Tamil Nadu state /TNBP
- d. CPWD
- e. Manufacturers recommendations

Respective CPWD specifications shall be followed for DSR items.

The Contractor shall also not be paid for any extra working space beyond concrete dimensions during excavation of foundations of various proposed structures in the Project. Any damage done to the work due to the contractor's operation beyond the excavation lines shall be repaired at the expense of the contractor. Any and all excess excavation or over breaking performed by the contractor for any purpose or reason except as may be ordered in writing by the PMC/EMPLOYER and whether or not due to the fault of the contractor shall be at the expense of the contractor. Cost of refilling for all such excavation with materials as specified by the PMC/EMPLOYER has to be done by the contractor at his expense.

2. LEED

To meet the LEED certification, required ingredients such as fly ash/GGBS to be added in required proportion to meet the strength requirements.

3. General

The scope of work shall comprise of (but not limited to) supply, construction, installation, testing, commissioning and approvals from PMC/EMPLOYER statutory authorities for all works described in the tender. Complete scope of works should be read in conjunction with all documents and drawings which are the part of tender. The drawings and documents attached in the tender document are for reference only.

The top layers of the site is of filled up earth and the same shall not be suitable for backfilling and it has to be disposed off. The non-serviceable material and surplus soil shall be disposed off to the designated approved dumping yard or as directed by the PMC/EMPLOYER. The contractor shall be responsible for all the statutory approvals from the statutory authority and all the concerned departments, as the case may be.

All materials shall conform to the latest edition of the Indian Standard Specifications. Standards issued elsewhere may be used only if approved by the PMC/EMPLOYER and for those materials only for which appropriate Indian Standards do not exist.

If specification for any material/work is not available in these Technical Specifications, the material/work shall conform to the latest Specifications, with up to date correction slips, amendments and additions / IS CODES / Manufacturers specifications / as per drawings / as per instructions of PMC/EMPLOYER.

The work shall be carried out according to the design, drawings and specifications issued by PMC/EMPLOYER as "Good for Construction" drawings from time to time during execution stage and approved by PMC/EMPLOYER.

All equipment and components shall be accommodated within the locations, space and dimensions indicated in the Architectural drawings. Any changes required shall be suggested by the Contractor and

submitted for approval of PMC/EMPLOYER. No changes shall be done without the approval of PMC/EMPLOYER.

All sections of Tender documents and Tender drawings shall complement each other. Any discrepancy between various documents shall be studied and implemented as best for the project and as per decision of PMC/EMPLOYER, without any cost implication.

The Tenderer has to ensure that all the designs, drawings, specifications and other things are in line with codal provisions applicable for the project and as per the requirements given by PMC/EMPLOYER.

If there is any variation in Design and Specifications between tender documents/drawings and any of the statutory/standard's requirement, then higher standard of specifications from either of them shall be implemented in approval with PMC/EMPLOYER. Nothing extra shall be payable on any account.

It shall be responsibility of the Contractor to ensure that all works are carried out in full compliance with the PMC/EMPLOYER's requirements, System Requirements.

Reference must be made to the General Specification for general requirements and to the appropriate Technical Specification for the corresponding technical requirements of all work.

The Specifications listed below have been added for guidance of the PMC/EMPLOYER responsible for carrying out the Works who shall however ensure that all aspects of the construction of the Works shall comply with Local Standards, Laws and Regulations and accepted good practice in India.

4. Contractor's Responsibility

Apart from carrying out necessary surveying and setting out of the buildings and equipment foundations wherever required collecting all materials, equipment, plant, labour, consumables, tools and services necessary for proper execution, fabrication, ensuring quality control by conducting required tests at the appropriate time and intervals during the execution, disposal of excavated material as instructed, carrying out all associated works like removal, disposal of the debris, getting out, remove temporary facilities on completion of the works, clearance from local bodies / authorities for commissioning of all installation / equipment of the project work shall be obtained and furnished before taking over of the completed work, all within the quoted rates only. Machinery operators, drivers should have valid license. Child labors are strictly prohibited. Top most attention shall be paid to the Health, safety of workers and Environment and the same shall be monitored on daily basis by qualified and experienced personnel in HSE.

1. EARTHWORK IN GRADING, EXCAVATION AND BACK FILLING**1.1. SCOPE**

This specification covers the general requirements of earthwork in excavation in different materials, site grading, filling in areas as shown in drawing, filling back around foundations and in plinths, conveyance and disposal of surplus soils or stacking them properly as shown on the drawings and as directed by the PMC/EMPLOYER and all operations covered within the intent and purpose of this specification.

1.2. APPLICABLE CODE

The following minimum codes and standards, unless otherwise specified herein, shall be applicable. In all cases, the latest revisions of the codes on the date of signing of contract agreement shall be referred to. The revisions in the relevant codes and standards after the date of award of contract shall be informed by the Contractor to the PMC/Employer within 30 days of the issue of such revision of the code/ standard. PMC/Employer may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

1	IS: 456	Code of practice for plain and reinforced concrete
2	IS: 783	Code of practice for laying of concrete pipes
3	IS: 1200	Method of measurement of Building and Civil Engineering works
	Part 1	Part 1 Earthwork
	Part 27	Part 27 Earthwork done by mechanical appliances
4	IS: 1498	Classification and Identification of Soils for General Engineering purposes
5	IS: 3764	Excavation work - code of safety
6	IS: 2720	Methods of test for soils
	Part 1	Preparation of dry soil samples for various tests
	Part 2	Determination of water content
	Part 4	Grain size analysis
	Part 5	Determination of liquid and plastic limit
	Part 7	Determination of water content - dry density relation using light compaction
	Part 9	Determination of dry density - moisture content relation by constant weight of soil method
	Part 14	Determination of density index (relative density) of cohesionless soils
	Part 28	Determination of dry density of soils in place, by the sand replacement method.
	Part 33	Determination of the density in place by the ring and water replacement method
	Part 34	Determination of density of soil in place by rubber balloon method
	Part 38	Compaction control test (HILF Method)
7	IS: 4081	Safety Code for Blasting and related Drilling Operations

1.3. DRAWINGS

The CONTRACTOR shall furnish good for construction drawings to the PMC/EMPLOYER for review and approval as applicable. Such drawings shall indicate areas to be excavated/ filled, grade levels, areas demarcated for stacking of excavated material etc. The contractor shall follow strictly such drawings and instruction given by the PMC/EMPLOYER.

1.4. GENERAL

1.4.1 The CONTRACTOR shall visit site to understand the site condition and make his own assessment about sub-soil strata and water level likely to be encountered during the execution.

1.4.2 The CONTRACTOR shall obtain written approval from the PMC/EMPLOYER on the execution method statement. Execution method statement prepared by contractor shall indicate the detailed sequential execution plan covering manpower & machinery, safety aspects, time duration etc. based on the project requirement. Contractor's execution methodology will include detailed calculation related to:

- Slope stability and or shoring by using parameters related to proposed site, if it is in contractor's scope otherwise the excavation drawing shall be followed.
- Dewatering.

However, the approval of construction methodology shall not in any way relieve the contractor of his responsibility for any consequent loss or damage. In case the project is expected to involve blasting, contractor will carry-out conditional survey of nearby properties to record it as a baseline prior to commencement of the excavation activities.

1.4.3 The Contractor shall at his own expense and without extra charges, take all precautions such as shoring for all depths or any other arrangement as approved by Engineer-in-charge for ensuring that there shall be no sliding / collapsing of the excavated earth. The measurement for excavation shall be regulated as per the provisions of the CPWD / MORTH specification and nothing extra shall be payable because of shoring /other arrangements.

1.4.4 The Contractor shall also not be paid for any extra working space beyond concrete dimensions during excavation of foundations of various proposed structures in the Project. Any damage done to the work due to the contractor's operation beyond the excavation lines shall be repaired at the expense of the contractor. Any and all excess excavation or over breaking performed by the contractor for any purpose or reason except as may be ordered in writing by PMC/EMPLOYER and whether or not due to the fault of the contractor shall be at the expense of the contractor. Cost of refilling for all such excavation with materials as specified by the PMC/EMPLOYER must be done by the contractor at his expense.

1.4.5 The contractor in accordance with the specification and project requirements shall mobilize all necessary tools, plants, qualified supervisory personnel, labour, instruments, materials (consumables and non-consumable) required for any temporary/permanent works etc., or any such items not specifically stated herein for completion of the job.

1.4.6 The CONTRACTOR shall carry out the detailed site survey prior to commencement of the site work and shall mark all footprints within + 10mm tolerance and record existing ground levels with respect to established reference/ grid lines at 10 m intervals or nearer or as determined by the PMC/EMPLOYER based on ground profile. Initially ground levels, finish ground level, depth of excavation etc., at every intermediate and final stages shall be confirmed with PMC/EMPLOYER and thereafter properly recorded.

- 1.4.7 The excavation shall be done to correct lines and levels within + 10mm tolerance. This shall also include, where required, proper shoring to protect the edges of excavation from soil collapse.
- 1.4.8 Temporary fences, guardrails, barricades, lights, and other protective measures around the excavation area required for the safety of personnel shall be provided and maintained in good condition.
- 1.4.9 The price quoted by CONTRACTOR shall also include for dumping of excavated materials in segregated manner within the areas demarcated, in regular heaps, bunds, riprap with regular slopes as directed by the PMC/EMPLOYER and levelling the same to provide natural drainage. Rock/soil excavated shall be stacked properly as directed by the PMC/EMPLOYER. As a rule, all softer material shall be laid along the centre of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Expansive, organic soil or any unsuitable soil, if encountered shall be stacked separately and shall not be used in any case for site grading activities. The surplus excavated earth shall be disposed by the CONTRACTOR at a designated location by the local authorities or as directed by PMC/EMPLOYER.
- 1.4.10 Known contaminated soils and water if any, shall be managed in accordance with approved soil management plan.
- 1.4.11 Soil erosion /sediment control shall be implemented in accordance with local authority regulations or approved erosion/sediment control measures.
- 1.4.12 Drainage of cuts, excavations, fills, stockpiles, spoil areas, surcharge embankments, and borrow areas shall always be maintained to prevent ponding of surface water because of ground water or rainfall by providing temporary ditches, swales, or pumping systems as required in each respective site area. Contractor shall submit management plan for the above-mentioned work along with work method statement.
- 1.4.13 The CONTRACTOR may, for facility of work or similar other reasons excavate, and backfill later, if so approved by the PMC/EMPLOYER, at his own cost outside the lines shown on the drawings or directed by the PMC/EMPLOYER. Should any excavation be taken below the specified elevations, the CONTRACTOR shall fill it up, with concrete of the same class as in the foundation resting thereon, up to the required elevation. No extra shall be claimed by the CONTRACTOR on this account.
- 1.4.14 The non-serviceable material and surplus soil shall be disposed off to the designated approved dumping yard or as directed by the PMC/EMPLOYER. The contractor shall be responsible for all the statutory approvals from the statutory authority and all the concerned departments, as the case may be.

1.5 QUALITY CONTROL AND SUBMITTALS

- 1.5.1 A written Quality Control Program document that provides details of how compliance with the requirements of this specification and contract documents shall be achieved and submitted by contractor to purchaser for approval a minimum of 14 days before start of construction.
- 1.5.2 Certified laboratory test data for the materials and products to be used in the work shall be submitted to purchaser for approval a minimum of 14 days before shipping of materials and products.
- 1.5.3 Results of the quality control tests required during the performance of the work shall be submitted to PMC/EMPLOYER within 2 days of completion.

1.5.4 An independent testing/inspection firm shall provide the following submittals to purchaser and contractor:

- A statement attesting that contractor's work is in accordance with the requirements of this specification and the contract documents.
- Informal daily "pass" or "fail" reports.
- Formal weekly reports including all test logs and comments. These formal reports shall include density and moisture content test logs, indicating location of tests by coordinates and elevation and all appropriate comments.
- Upon earthwork completion, all density and moisture content test logs and comments compiled and submitted for permanent project records.
- Sources and test results of all borrow materials used for fill.

1.6 QUALITY ASSURANCE

1.6.1 Unless otherwise specified in the contract documents, a qualified independent inspection and testing agency will be retained by purchaser to perform field and laboratory testing and/or evaluations in accordance with the criteria of ASTM D3740 to verify compliance of the work with the requirements of this specification and to ensure the achievement of the intents and purposes of the work.

1.6.2 The performance or lack of performance of the tests and inspections by purchaser's inspector shall not be construed as granting relief from the requirements of this specification or the other contract documents.

1.6.3 During construction, purchaser shall have access to all contractor's facilities and records for conducting performance inspection/audits.

1.6.4 During an audit by purchaser, all inspection and test reports, and/or engineering analyses and calculations associated with the scope of work shall be provided to purchaser upon request.

1.7 CLEARING

The areas to be excavated/ filled shall be cleared of fences, trees, plants, logs, stumps, bush, vegetation, rubbish, slush, etc. and other objectionable matter. If any roots or stumps of trees are met during excavation, they shall also be removed. The material so removed shall be burnt or disposed as directed by local authorities or PMC/EMPLOYER. Where earth fill is intended, the area shall be stripped of all loose/ soft patches, topsoil containing objectionable matter/ materials before fill commences.

1.8 PRECIOUS OBJECTS, RELICS, OBJECTS OF ANTIQUITY, ETC.

All gold, silver, oil, minerals, archaeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the site shall be the property of the EMPLOYER and the CONTRACTOR shall duly preserve the same to the satisfaction of the EMPLOYER and from time to time deliver the same to such person or persons as the EMPLOYER may from time to time authorise or appoint to receive the same.

1.9 CLASSIFICATION

All materials to be excavated shall be classified by the PMC/EMPLOYER, into one of the following classes. The decision of the PMC/EMPLOYER regarding the classification of the material shall be final and binding on the CONTRACTOR and not be a subject matter of any appeal or arbitration.

Earthwork will be classified under any of the following categories:

- **Ordinary and Hard Soils:**

These shall include all kinds of soils containing sand, silt, shingle, gravel, clay, loam, peat, ash, shale, etc., which can be easily excavated either manually or mechanically.

- **Soft and Decomposed Rock:**

This shall include completely to highly weathered/fractured rock, boulders, slag, chalk, slate, hard mica schist, laterite and all other materials, which in the opinion of PMC/EMPLOYER is soft rock, difficult to excavate manually with a pick axe or required very light mechanical excavating machines but does not need blasting. The mere fact that the CONTRACTOR resorts to blasting without prior approval from local authorities or PMC/EMPLOYER, shall not qualify for classification under 'Hard Rock'.

This shall also include excavation in macadam & tar roads and pavements, rock boulders not longer than 1 metre in any direction and not more than 500 mm in any one of the other two directions.

- **Hard Rock:**

This shall include all rock occurring in large continuous masses, which can only be excavated by blasting or by Pneumatic hydraulic breakers. Harder varieties of rock with or without veins and secondary minerals, which in the opinion of the PMC/EMPLOYER require blasting, shall be considered as hard rock.

Where hard rock is met with and blasting operations are not permitted, the CONTRACTOR shall use other methods such as use of chemicals or Pneumatic hydraulic breakers or any other method approved by the PMC/EMPLOYER for loosening the rock mass, developing cracks, etc. The loosened material shall be thereafter removed mechanically. Boulders of rock occurring in such sizes and not classified under (a) and (b) above shall also be classified as hard rock. Buried concrete work both reinforced and unreinforced to be dismantled will be measured under this item, unless a separate provision is made in the tender.

1.10 EXCAVATION

- 1.10.1 Contractor shall obtain written permission from intra departmental heads prior to commencement of work to ensure that there is no presence of underground utilities in the proposed excavation area.
- 1.10.2 All the required work permits shall be obtained by CONTRACTOR from the EMPLOYER / PMC/EMPLOYER / LOCAL AUTHORITIES / GOVERNMENT AGENCY, as applicable.
- 1.10.3 In case of existence of underground utilities, the same shall be diverted away from the excavation area in consultation with the PMC/EMPLOYER. Payment of Diversion of utilities shall be made as per the item specified in the tender and if there is no provision in the tender then the same shall be executed based on the mutually agreed terms with the PMC/EMPLOYER.
- 1.10.4 Excavation for permanent work shall be carried out as per the approved drawings. In area involving mass excavation, initially area shall be excavated up to a depth 150 mm above the final level. The balance depth shall be excavated with special care just prior (not more than 12 hours before) the laying of P.C.C. Soft pockets, if any, shall be removed even by excavating below the final level and extra excavation shall be filled up using Lean concrete or plum concrete or plain cement concrete as directed by the PMC/EMPLOYER. It should be ensured that the foundation shall rest on single type of strata. The strata once excavated should not be exposed to environment to avoid degradation.
- 1.10.5 All excavation shall be done to the minimum dimensions as required for safety and working facility. The excavation must be carried out in the most expeditious and efficient manner. Where the nature of soil or the depth of the trench and season of the year do not permit vertical sides,

the CONTRACTOR shall erect the necessary shoring, strutting and planking or cut slopes with or without steps, to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the PMC/EMPLOYER. The scheme proposed by the CONTRACTOR shall take into consideration the presence of existing buildings/ structures/traffic movement in the vicinity, if any. All necessary precautions shall be taken to avoid slipping of loose soil / rock.

- 1.10.6 In case of deep excavation in rocky strata the fractured excavated rock sides shall be stabilised by using rock anchors.
- 1.10.7 The CONTRACTOR shall make all necessary pumping arrangements for dewatering the low-lying area or area where excavation is required to carry out below ground water table. CONTRACTOR shall keep area under execution to be workable. The low-lying areas may receive water from any source such as rains, accumulated rainwater, floods, leakages from sewer and water mains, water ingress from near-by canals / channels, subsoil water table being high or due to any other cause whatsoever.
- 1.10.8 In case of deep excavation in the area of high-water table special precautions shall be taken to main water table level at least 500 mm below the layer of binding concrete (Plain Cement Concrete (PCC) level to avoid uplift/damage of building basement raft/foundation due to water pressure. The water table shall not be allowed to rise above base of raft/foundation level until the structure attains adequate height required to counterbalance the uplift pressure.
- 1.10.9 The CONTRACTOR shall take all necessary precautions for the safety of traffic during construction and provide, erect and maintain such barricades including signs, markings, flags, lights and flagman, as necessary at either end of the excavation/ embankment and at such intermediate points as directed by the PMC/EMPLOYER for the proper identification of construction area. He shall be responsible for all damages and accidents caused due to negligence on his part.

1.11 STRIPPING LOOSE ROCK

- 1.11.1 All loose boulders, semi-detached rocks (along with earthy stuff, which might move therewith) which is not directly in the excavation but so close to the area to be excavated, and in the opinion of the PMC/EMPLOYER liable to fall or otherwise endanger the workmen, equipment, or the work, etc., shall be stripped off and removed away from the area of the excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion, which is originally sound and safe.
- 1.11.2 Any material not requiring removal as contemplated in the work, but which, in the opinion of the PMC/EMPLOYER, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by the PMC/EMPLOYER.

1.12 EXCAVATION IN HARD ROCK

- 1.12.1 After removal of overburden, if any, excavation is likely to continue in rock to adequate depths and area of excavation footprint shown in the drawings and if the site condition permits to excavate rock by using blasting, then as far as possible, all blasting operations shall be completed prior to commencement of other construction activities.
- 1.12.2 All precautions shall be taken by the contractor during the blasting operations so that no damage is caused to adjoining buildings or structures because of blasting operations. In case of any damage to permanent or temporary structures, CONTRACTOR shall repair the same to the satisfaction of PMC/EMPLOYER at his cost.

1.12.3 Specific permission of PMC/EMPLOYER shall be taken by CONTRACTOR for blasting rock and he shall also obtain a valid Blasting License from the authorities concerned. If permission for blasting is refused by either by PMC/EMPLOYER or by local authority, the rock shall be removed by wedging, pick, barring, heating and quenching, pneumatic hydraulic breakers etc., or other approved methods including chemicals required if any. All loose or loosened rock in the sides shall be removed by barring, wedging, etc. and if any unstable wedges of rock mass from sides of excavated surface shall be stabilised by providing temporary rock bolts. The price quoted by contractor for excavation in hard rock shall include the cost of all these operations. Safety net shall be used to arrest the movement of fractured rocks as a safety precaution for the workers working inside the pit.

1.12.4 In no case shall blasting be allowed closer than 30 metres from any structure or at locations where concrete has just been placed. In the latter case, the concrete must be at least 7 days old.

1.13 FILL MATERIAL FOR BACK FILLING AND SITE GRADING

1.13.1 GENERAL

All fill material will be subject to the PMC/EMPLOYER's approval. If any material is rejected by the PMC/EMPLOYER, the CONTRACTOR shall remove the same forth with from the site at no extra cost to the EMPLOYER. Surplus fill material shall be deposited/ disposed as directed by the PMC/EMPLOYER after the fill work is completed. No earth fill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by the PMC/EMPLOYER.

1.13.2 EXCAVATED SOIL

To the extent available, selected surplus soils from excavated materials shall be used as backfill subject to the approval based on the below test results. Contractor shall categorise the surplus excavated material and stack separately. Fill material shall be free from clods, salts, sulphates, organic or other foreign material and non-expansive in nature. The CONTRACTOR shall arrange **at his cost** to carry out the minimum following tests on selected soil samples from excavated material in an accredited geotechnical laboratory

- a) Grain size analysis
- b) Moisture content
- c) In-situ density
- d) Specific gravity
- e) Liquid limit and plastic limit
- f) Standard/Modified proctor density (based on project requirement) or relative density (in case of sandy strata)
- g) Free swell Index and Swelling pressure.
- h) Tri- axial test / direct shear test under undrained and unconsolidated condition.

1.13.3 BORROWED MATERIAL:

If any selected fill material is required to be borrowed, it shall be CONTRACTOR'S responsibility to locate suitable borrow areas for borrowing fill material, the CONTRACTOR shall decide for bringing such material from outside borrow pits. The material and source shall be subject to prior approval of the PMC/EMPLOYER. The approved borrow pit area shall be cleared of all bushes, roots of trees, plants, rubbish, etc. Top loose soil containing salts/ sulphates and other foreign material shall be removed and disposed to an approved designated location as instructed by the PMC/EMPLOYER. The CONTRACTOR shall arrange to have trial pits of specified dimensions and numbers dug at locations specified, for the PMC/EMPLOYER to examine the nature and type of material to be obtained from the borrow area. Any material rejected by the PMC/EMPLOYER shall be removed from the site

immediately. The CONTRACTOR shall make necessary access road to the borrow areas and maintain the same, if such access road does not exist, CONTRACTOR shall obtain all necessary permits from local authorities.

The properties of borrow material shall meet following requirements:

SL	Properties	Range of Values
1	Field Characteristics	
1.1	Bulk Density (γ_{bulk})	1.8 to 2.1 gm/cc
1.2	Dry density (γ_{dry})	1.3 to 1.6 gm/cc
1.3	Moisture content	34 to 36 %
1.4	Modified Proctor Density	More than 1.8 gm/cc
2	Physical Properties	
2.1	Specific gravity	2.65 to 2.85
3	Index properties	
3.1	Liquid limit (%)	40 to 65%
3.2	Plastic Limit (%)	20 to 25 %
3.3	Shrinkage limit (%)	15 to 35 %
3.4	Free swelling index	Less than 50%
4	Mechanical analysis	
4.1	Gravel (above 2.0 mm)	0 to 10%
4.2	Sand (2.0 to 0.06 mm)	30 to 40%
4.3	Silt (0.06 to 0.002 mm)	0 to 45 %
4.4	Clay (Below 0.002 mm)	15 to 25 %
5.0	Chemical properties	
5.1	Loss on ignition	3.5-4.5
5.2	Chloride (Cl)	Less than 500 mg/litre
5.3	Sulphate (SO_3)	Less than 400 mg/litre
6	Engineering properties	
6.1	C (kg/cm^2)	0.2-0.3
6.2	Φ	10 to 25 degree
6.3	Permeability K (cm/sec)	10^{-4} to 10^{-5}
6.4	CBR (%)	3 -6

Filling with excavated earth shall be done in regular horizontal layers each not exceeding 150 mm in depth, well rammed, watered and consolidated. All lumps and clods exceeding 125 mm in any direction shall be broken. The CONTRACTOR shall make good all subsidence and shrinkage in earth fillings, embankments, traverses, etc. during execution and till the completion of work unless otherwise specified.

1.14 FILLING IN PITS AND TRENCHES AROUND FOUNDATIONS OF STRUCTURES, WALLS, ETC

As soon as the work in foundations has been accepted (after attaining 28 days strength) and measured, the spaces around the foundations, structures, pits, trenches, etc. shall be cleared of all debris, and filled with earth in layers as specified above., each layer being watered, rammed and properly compacted, before the succeeding one is laid. Each layer shall be compacted to the satisfaction of the PMC/EMPLOYER. The final backfill surface shall be trimmed and levelled to proper profile as directed by the PMC/EMPLOYER or indicated on the drawings. Backfilling for the retaining wall shall be done after the construction of upper level slabs and curing and deshuttering is done.

1.15 PLINTH FILLING

Plinth filling shall be carried out with approved material and shall be filled in layers as specified above, watered and compacted with mechanical compaction machines. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at a later stage. The finished level of the filling shall be trimmed to the level/ slope specified.

At some locations/ areas it may not be possible to use rollers because of space restrictions, etc. The CONTRACTOR, if permitted by a PMC/EMPLOYER, shall use pneumatic tampers, rammers, etc. to ensure proper compaction.

1.16 FILLING IN TRENCHES

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed. The backfilling material shall be properly compacted by watering and ramming, taking due care that no damage is caused to the pipes.

Where the trenches are excavated in soil, the filling from the bottom of the trench to the level of the centre line of the pipe shall be done with selected approved earth in layers; backfilling above the level of the centre line of the pipe shall be done with selected earth in layers with proper compaction of each layer. For Piping, trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. Backfilling should be placed in layers not exceeding 15 cm thickness per layer and should be compacted to a minimum of 95% maximum dry density.

In case of excavation of trenches in rock, the filling up to a level 300 mm above the top of the pipe shall be done with fine materials. The filling from a level 300mm above the top of the pipe to the top of the trench shall be done using broken rock filling of size not exceeding 150mm mixed with fine material as available to fill up the voids.

Filling of the trenches shall be carried simultaneously on both sides of the pipe to avoid unequal pressure on the pipe.

The Contractor is requested to provide the method of Backfilling compaction test and evaluation value and obtain the approval from the PMC/EMPLOYER

It is very important that the pipe zone backfill material does not wash away or migrate into the native soil. Likewise, potential migration of the native soil into the pipe zone backfill must also be prevented.

1.17 GENERAL SITE GRADING

Site grading shall be carried out as indicated in the drawings and as directed by the PMC/EMPLOYER. Excavation shall be carried out as specified under relevant clauses.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the CONTRACTOR.

Field compaction test shall be carried out as per relevant standard at different stages of filling and also after the fill to the entire height has been completed.

The CONTRACTOR shall protect the earth-fill from being eroded or washed away by rain or damaged in any other way. Should any slip occur, the CONTRACTOR shall remove the affected material and make good the slip at his cost.

The fill shall be carried out to such dimensions and levels as indicated on the drawings after the stipulated compaction. The fill shall be considered as incomplete if the desired compaction has not been achieved.

Access roads, whether of temporary or other nature, required to be constructed for access and for movement of men, materials, equipment, transport vehicles, vehicles carrying fill material, etc. to or over borrow areas and/ or to or over areas on which fill must be deposited shall be constructed by the CONTRACTOR. Such access roads shall be maintained in good condition during all seasons to ensure completion of work according to time schedule.

1.18 MEASUREMENT AND PAYMENT FOR ITEM RATE CONTRACT

- 1.18.1 All excavation shall be measured net. Dimensions for purpose of payment shall be reckoned on the horizontal area of the excavation at the base for foundations of the walls, columns, footings, tanks, rafts or other foundations/ structures to be built, multiplied by the mean depth from the surface of the ground in accordance with the foundation drawings. Excavation inside slopes will not be paid for. The CONTRACTOR may make such allowance in his rates to provide for excavation inside slopes keeping in mind the nature of the soil and safety of excavation. However, if the concreting is proposed against the excavated sides, no such over excavation will be permitted. In such cases, over excavation shall be made good by the CONTRACTOR with concrete of the same class as in the foundations at his cost.
- 1.18.2 Unless otherwise specified, the unit rates quoted for excavation in different types of material shall also account for a basic lead as mentioned in BOQ for disposal as specified or directed. Only leads beyond the basic lead will be considered as extra lead and paid for at the rates quoted in the schedules.
- 1.18.3 Backfilling, as per specification, the sides of foundations of columns, footings, structures, walls, tanks, rafts, trenches, etc. with excavated material will not be paid for separately. It shall be clearly understood that the rate quoted for excavation including backfilling shall include stacking of excavated material as directed, excavation/ packing of selected stacked material, conveying it to the place of final backfill, compaction, etc. as specified. As a rule, material to be backfilled shall be stacked temporarily within the basic lead unless otherwise directed by the PMC/EMPLOYER. If the PMC/EMPLOYER directs/ permits a lead for such material, the conveyance of the material for the extra distance over the basic lead for backfilling will be paid for.
- 1.18.4 Payment for fill inside trenches, plinth or similar filling with selected excavated material will be made for only compacted soil volume as specified/ directed. Cost of all other operations shall be deemed to have been covered in the rate quoted for filling. Payment for this work will be

made based on measurement of plinth/ trench dimensions filled. The plinth ground levels shall be surveyed before for this purpose. If no compaction is specified/ desired, such filling will not be separately paid for. In such an event the fill shall be levelled/ finished to the profile as directed at no extra cost.

- 1.18.5 Backfilling, plinth filling, etc. with borrowed earth will be paid for at rates quoted. The quoted rate shall include all operations such as clearing, excavation, lead and transport, fill, compaction, etc. as specified. Actual quantity of consolidated filling shall be measured and paid for in cubic metres. The lead, lift, etc. shall be as indicated in the Schedule of Quantities.
- 1.18.6 Actual quantity of consolidated sand filling shall be measured and paid in cubic metres
- 1.18.7 Volume of rock excavated shall be calculated based on length, breadth and depth of excavation dimension as per the foundation drawings.
- 1.18.8 No payment will be made for excavations/ over-break beyond payment line specified. Where such measurement is not possible as in the case of strata intermixed with soil, excavated rock shall be properly stacked as directed by PMC/EMPLOYER and the volume of rock calculated based on stack measurements after making appropriate allowance for voids. The allowance to be made for voids shall be decided by PMC/EMPLOYER and this will not be a subject matter of dispute or appeal.
- 1.18.9 Measurement for Site Filling will be made based on this specification

2 DEWATERING

2.1 SCOPE

This specification covers the general requirements of dewatering excavations in general.

2.2 GENERAL

- 2.2.1 All excavations shall be kept free of water. Grading and surface water drainage scheme in the vicinity of excavation shall be properly closed to prevent surface water from draining into excavated areas. CONTRACTOR shall remove by pumping or other means approved by PMC/EMPLOYER any water inclusive of rain water and subsoil water accumulated in excavation and keep all excavations dewatered until the foundation work is completed and backfilled. Sumps made for dewatering must be kept clear of the excavation/ trench areas required for further work of foundation construction. Method of pumping shall be approved by PMC/EMPLOYER; but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in or excavation wall collapse due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.
- 2.2.2 The CONTRACTOR shall take adequate measures for bailing and/ or pumping out water from excavations and construct diversion channels, bunds, sumps, coffer dams, etc. as may be required. Pumping shall be done directly from the foundation trenches or from a sump outside the excavation in such a manner as to preclude the possibility of movement of water through any fresh concrete or masonry and washing away parts of concrete or mortar. During laying of concrete or masonry and for a period of at least 24 hours thereafter, pumping shall be done to ensure that the surface below the concrete remains dry.
- 2.2.3 Capacity and number of pumps, location at which the pumps are to be installed, pumping hours, etc. shall be reviewed by the CONTRACTOR from time to time. The PMC/EMPLOYER may direct the CONTRACTOR to make changes in his scheme if the adopted scheme fails to achieve the desired results.
- 2.2.4 Pumping shall be done in such a way as not to cause damage to the work or adjoining property by subsidence, etc. Disposal of water shall not cause inconvenience or nuisance in the area or cause damage to the property and structures nearby or shall not be a cause for environmental pollution of natural water bodies.
- 2.2.5 When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of PMC/EMPLOYER as large, well point system - Single stage or multi stage, shall be adopted. CONTRACTOR shall submit to PMC/EMPLOYER his scheme of well point system including the stages, the spacing, number and diameter of well points, headers, etc. and the numbers, capacity and location of pumps of approvals. Normal dewatering using bailing arrangement, submersible pumps shall be included in the item rate for excavation. Special dewatering system using well point system shall be considered as separate item.
- 2.2.6 In case well point dewatering is required, the Indian Standard IS 9759: 1981 (Reaffirmed 2016) - Guidelines for De-Watering During Construction shall be used for design of the dewatering system.

3 REINFORCED CONCRETE AND ALLIED WORKS**3.1 SCOPE**

This Specification covers the general requirements for ready mixed concrete and for concrete using on-site production facilities including requirements with regard to the quality, handling, storage of ingredients, proportioning, batching, mixing, transporting, placing, curing, protecting, repairing, finishing and testing of concrete; formwork; requirements with regard to the quality, storage, bending and fixing of reinforcement; grouting as well as mode of measurement and payment for completed works.

It shall be very clearly understood that the specifications given herein are brief and do not cover minute details. However, all works shall have to be carried out in accordance with the relevant standards and codes of practices or in their absence in accordance with the best accepted current Engineering practices or as directed by PMC/EMPLOYER from time to time. The decision of PMC/EMPLOYER about the specification to be adopted and their interpretation and the mode of execution of work shall be final and binding on CONTRACTOR and no claim whatsoever will be entertained on this account.

3.2 APPLICABLE CODES AND SPECIFICATIONS

The following specifications, standards and codes, including all official amendments/ revisions and other specifications and codes referred to therein, should be considered a part of this specification. In all cases the latest issue/ edition/ revision shall apply. In case of discrepancy between this specification and those referred to herein below or other specifications forming a part of this bid document, this specification shall govern.

3.2.1 MATERIALS:

IS 455	Specification for Portland Slag Cement.
IS 1489: PART 1	Portland pozzolana cement - specification part 1 fly ash based
IS 1489: PART 2	Portland pozzolana cement - specification part 2 calcined clay based (fourth revision)
IS 12330	Specification for Sulphate Resisting Portland Cement
IS 383	Coarse and fine aggregate for concrete - specification (third revision)
IS 432	Specification for Mild Steel and Medium Tensile Steel Bars and Hand Drawn Steel Wire for Concrete Reinforcement – Part 1 and 2
IS 1786	High strength deformed steel bars and wires for concrete reinforcement - specification
IS 1566	Specification for hard-drawn steel wire fabric for concrete reinforcement
IS 9103	Concrete admixtures - specification
IS 2645	Integral waterproofing compounds for cement mortar and concrete - specification
IS 4990	Plywood for concrete shuttering work - specification
IS 4926	Ready-mixed concrete - code of practice
IS 8041	Specification for rapid hardening cement.
IS 12600	Specification for Low Heat Portland Cement
IS 6909	Specification for super-sulphated cement

IS 12089	Specification for granulated slag for manufacture of portland slag cement

3.2.2 MATERIAL TESTING

IS 4031 (Part 1 to 15)	Methods of physical tests for hydraulic cement
IS 4032	Method of chemical analysis of hydraulic cement.
IS 650	Specification for standard sand for testing of cement.
IS 2430	Methods for sampling of aggregates for concrete.
DIN EN 12620	Aggregates for concrete (Refer Note).
IS 2386	Methods of test for aggregates for concrete (Parts 1 to 8)
IS 3025 (Part 1 to 51)	Methods of sampling and test (physical and chemical) for water and wastewater
ISS 6925	Methods of test for determination of water-soluble chlorides in concrete admixtures

NOTE: These tests are optional and shall be carried out by the contractor at his cost, if directed by PMC/EMPLOYER.

3.2.3 MATERIAL STORAGE

IS 4082	Recommendations on stacking and storage of construction materials and components at site.

3.2.4 CONCRETE MIX DESIGN

IS 10262	Concrete mix proportioning-guidelines

3.2.5 CONCRETE TESTING

IS 1199	Method of sampling and analysis of concrete.
IS 516	Method of test for strength of concrete.
IS 9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
IS 8142	Method of test for determining setting time of concrete by penetration resistance.
IS 9284	Method of test for abrasion resistance of concrete.
IS 2770 (Part 1)	Methods of testing bond in reinforced concrete: Part 1 Pull-out test

3.2.6 EQUIPMENT

IS 4925	Specification for concrete batching and mixing plant.
IS 7251	Specification for concrete finishers.
IS 2750	Specifications for steel scaffoldings.

3.2.7 CODES OF PRACTICE

IS: 456	Plain and reinforced concrete - code of practice.
IS: 457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
IS 3370 (Part 1)	Concrete structures for storage of liquids - code of practice - part 1 : general requirements
IS 3370 (Part 2)	Concrete structures for storage of liquids - code of practice - part 2 : reinforced concrete structures
IS 3370 (Part 3)	Code of practice for concrete structures for the storage of liquids: part 3 prestressed concrete structures
IS 3370 (Part 4)	Code of practice for concrete structures for the storage of liquids: part 4 design tables
IS 3935	Code of practice for composite construction.
IS 2204	Code of practice for construction of reinforced concrete shell roof.
IS 2210	Criteria for the design of reinforced concrete shell structures and folded plates.
IS 2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS 5525	Recommendation for detailing of reinforcement in reinforced concrete works.
IS 2751	Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.
IS 9417	Welding of high strength steel bars for reinforced concrete construction-recommendations
IS 3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS 3414	Code of practice for design and installation of joints in buildings.
IS 4326	Earthquake resistant design and construction of buildings - code of practice
IS 4014 (Part 1)	Code of practice for steel tubular scaffolding Part 1 Definitions and materials
IS 4014 (Part 2)	Code of practice for steel tubular scaffolding: Part 2 Safety regulations for scaffolding (first revision)
IS 2571	Code of practice for laying in situ cement concrete flooring
IS 7861 (Part 1)	Code of practice for extreme weather concreting: Part 1 Recommended practice for hot weather concreting

IS 7861 (Part 2)	Code of practice for extreme weather concreting: Part 2 Recommended practice for cold weather concreting
IS 3812 (Part 1)	Pulverized fuel ash – Part 1 – For use as pozzolana in cement, cement mortar and concrete
IS 15388: 2003	Specification for Silica Fume

3.2.8 CONSTRUCTION SAFETY

IS 3696 (Part 1)	Safety code of scaffolds and ladders: Part 1 Scaffolds (first revision)
IS 3696 (Part 2)	Safety code of scaffolds and ladders: Part 2 Ladders (first revision)
IS 7969	Safety code for handling and storage of building materials.
IS 8989	Safety code for erection of concrete framed structures.

3.2.9 MEASUREMENT

IS 1200 (Part 2)	Method of measurement of building and Engineering works (Part 2 and 5) Methods of measurement of building and civil engineering works: Part 2 Concrete works (third revision)
IS 1200 (Part 5)	Methods of measurement of building and civil engineering works: part 5 Form work (fourth revision)

3.3 GENERAL

PMC/EMPLOYER shall always have the right to inspect all operations including the sources of materials, procurement, layout and storage of materials, the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged, and PMC/EMPLOYER's approval obtained, prior to starting of concrete work. This shall, however, not relieve CONTRACTOR of any of his responsibilities. All materials, which do not conform to this specification, shall be rejected.

Materials should be selected so that they can satisfy the design requirements of strength, serviceability, safety, durability and finish with due regards to the functional requirements and the environmental conditions to which the structure will be subjected. Materials complying with codes/ standards shall only be used. Other materials may be used after approval of the PMC/EMPLOYER and after establishing their performance suitability based on previous data, experience or tests.

3.4 MATERIALS

3.4.1 CEMENT

3.4.1.1 The Portland Pozzolana Cement shall conform to IS: 1489 & Portland Slag Cement conforming to IS: 455 shall be used as directed by PMC/EMPLOYER.

3.4.1.2 Sulphate Resisting Portland Cement conforming to IS: 12330 may be used for mass concrete construction and generally complying with IS: 12330, but with Tricalcium Aluminate (C3A) content not more than 5% by mass (as manufactured by an approved manufacturer) may be used for reinforced concrete construction.

3.4.1.3 Fly Ash Blended Cements conforming to IS: 1489 (Part I) or GGBS blended cements conforming to IS 16715 may be used in RCC structures as per the guidelines given below:

- IS: 456 - Code of Practice for Plain and Reinforced Concrete shall be followed about Concrete Mix Proportion and its production.
- The concrete mix design shall be done as “Design Mix Concrete” as prescribed in clause 9 of IS: 456.
- Concrete shall be manufactured in accordance with Clause 10 of IS 456 covering Quality Assurance measures.
- Minimum M25 grade of concrete shall be used in all structural elements made with RCC both in load bearing and framed structure.
- The mechanical properties such as modulus of elasticity, tensile strength, creep and shrinkage of fly ash mixed concrete or concrete using fly ash blended cements (PPCs) are not likely to be significantly different and their values are to be taken same as those used for concrete made with OPC.
- If necessitated due to low water/ binder ratio, required workability shall be achieved by use of chloride free chemical admixtures conforming to IS: 9103. The compatibility of chemical admixtures and super plasticisers with each set OPC, fly ash and/ or PPC received from different sources shall be ensured by trials.
In cases, where structural concrete is exposed to excessive magnesium sulphate, fly ash substitution/ content shall be limited to 18% by weight. Special type of cement with low C3A content may also be alternatively used. Durability criteria like minimum binder content and maximum water/ binder ratio also need to be given due consideration in such environment.
- Wet curing period shall be enhanced to a minimum of 10 days or its equivalent. In hot and arid regions, the minimum curing period shall be 14 days or its equivalent.

3.4.1.4 Use of Fly Ash Admixed Cement Concrete (FACC) in RCC Structures

There shall be no bar on use of FACC in RCC structures subject to following additional conditions.

- Fly ash shall have its chemical characteristics and physical requirements, etc. conforming to IS: 3812 (Parts I) and shall be duly certified.
- To ensure uniform blending of fly ash with cement in conformity with IS: 456, a specific facility needs to be created at site with complete computerised automated process control to achieve design quality or with similar facility from Ready Mix Concrete (RMC) plants.
- As per IS: 1489 (Part-I) maximum 35% of mass of total cementitious material is permitted to be substituted with fly ash conforming to IS: 3812 (Part-I).
- Separate storage for dry fly ash shall be provided. Storage bins or silos shall be weather proof and permit a free flow and efficient discharge of fly ash. The filter or dust control system provided in the bins or silos shall be of sufficient size to allow delivery of fly ash maintained at specified pressure to prevent undue emission of fly ash dust, which may interfere with weighing accuracy.

3.4.1.5 Use of Silica Fume Admixed Cement Concrete in RCC Structures

Silica fume conforming to IS 15388 may be used to the extent of 5 – 10% of the cement content as stipulated in IS 456 as a part replacement of cement.

3.4.1.6 Use of Fly Ash Blended Cements in Cement Concrete (PPCC) in RCC Structures

- Subject to General Guidelines detailed out as above, PPC manufactured conforming to IS: 1489 (Part-I) shall be treated at par with OPC for manufacture of Design Mix concrete for structural use in RCC.

- Till the time, Bureau of Indian Standards (BIS) makes it mandatory to print the percentage of fly ash on each bag of cement, the certificate from the PPC manufacture indicating the same shall be insisted upon before allowing use of such cements in works.
- While using PPC for structural concrete work, no further admixing of fly ash shall be permitted.

Only one type of cement shall be used in any one mix unless specifically approved by PMC/EMPLOYER. The source of supply, type or brand of cement within the same structure or portion thereof shall not be changed without prior approval from PMC/EMPLOYER.

Cement, which is not used within 90 days from its date of manufacture, shall be tested at a laboratory approved by PMC/EMPLOYER and until the results of such tests are found satisfactory, it shall not be used in any work.

3.4.2 AGGREGATES

Aggregates shall consist of naturally occurring stones and gravel (crushed or uncrushed) and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of limited porosity, free from dust/ silt/ organic impurities/ deleterious materials and conform to IS: 383. Aggregates such as slag, crushed over burnt bricks, bloated clay ash, sintered fly ash and tiles shall not be used.

Aggregates shall be washed and screened before use where necessary or if directed by the PMC/EMPLOYER.

Aggregates containing reactive materials shall be used only after tests conclusively prove that there will be no adverse effect on strength, durability and finish, including long term effects, on the concrete.

The fineness modulus of sand shall neither be less than 2.2 nor more than 3.2. If use of sand having fineness modulus more than 3.2 is unavoidable then it shall be suitable blended with crusher stone dust.

Plums 160 mm and above of a reasonable size may be used where directed. Plums shall not constitute more than 20% by volume of concrete unless specified by PMC/EMPLOYER.

3.4.3 WATER

Water used for both mixing and curing shall conform to IS: 456. Potable water is generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used. The pH value of water shall not be less than 6. Seawater shall not be used for concrete mixing and curing.

3.4.4 REINFORCEMENT

Reinforcement bars shall conform to IS: 432 and/ or IS: 1786 and welded wire fabric to IS: 1566 as shown on the drawing.

All reinforcement shall be clean, free from pitting, oil, grease, paint, loose mill scales, rust, dirt, dust or any other substance that will destroy or reduce bond.

Special precaution like coating of reinforcement may be provided with the prior approval of PMC/EMPLOYER.

Reinforcement bars produced by rerolling may be used subject to the approval of the PMC/EMPLOYER. CONTRACTOR shall furnish the manufacturer's certificate stating the process of manufacture to the satisfaction of the PMC/EMPLOYER and the test sheet signed by the manufacturer giving the result of each mechanical test applicable for each lot of the material supplied including result of chemical composition. At-least one Sample from each lot received at site shall be tested in the laboratory

approved by the PMC/EMPLOYER and the cost of testing shall be borne by the CONTRACTOR. It shall be ensured that all the test results conform to IS: 432 or IS: 1786 as applicable.

3.4.5 ADMIXTURES AND ADDITIVES

3.4.5.1 Approval of Admixtures

Admixture from approved manufacturer shall be used in concrete mix along with aggregates, cement and water without the written instruction or approval of the PMC/EMPLOYER in each case. If more than one admixture is proposed for use in the same concrete mix, their interaction shall be checked by trial mixes to ensure their compatibility.

The CONTRACTOR shall note that the description of any proposed admixture by trade or brand name will not be enough for the approval of the PMC/EMPLOYER.

The CONTRACTOR shall submit manufacturer's test certificates and technical literature of the admixture proposed to be used. If directed by the PMC/EMPLOYER, the admixture shall be got tested at an approved laboratory at no extra cost.

The PMC/EMPLOYER will, wherever appropriate, call for trial batches of concrete to be prepared to demonstrate the effect of the proposed admixtures both on the fresh concrete and on the hardened concrete before giving his approval. He may also lay down additional requirements for the control of the use of such admixtures.

Notwithstanding any previously given approval, the PMC/EMPLOYER may withdraw such approval at any time with respect to any mix containing admixtures if, in his opinion, the performance of the admixture under actual Site conditions is not completely satisfactory.

3.4.5.2 Supply and Storage of Admixtures

Accelerating, retarding, water-reducing, super plasticizing and air entraining admixtures shall conform to IS: 9103, integral cement water proofing admixture to IS: 2645, any other admixture to BS: 5075, if it is applicable, unless otherwise specified or agreed. Admixtures shall be stored strictly in accordance with manufacturers' recommendations and precautions shall be taken during delivery and storage to prevent damage to or adulteration of admixtures.

3.4.5.3 Use of Admixtures

Any admixture used in any concrete mix shall only be used at the rate of dosage or in the proportions previously approved by the PMC/EMPLOYER, method of mixing, etc. all in accordance with the manufacturer's instructions and within the manufacturer's recommended ambient temperature range.

Any batch of concrete, which has received an incorrect dose of an admixture or which shall show deterioration after placing because of incorrect use of admixtures, shall be broken out or otherwise replaced at no additional cost to the EMPLOYER.

The relative density of liquid admixtures shall be checked for each drum containing the admixture and compared with the stated/ specified value before acceptance. Liquid admixtures or powder admixtures that are to be used as solutions shall be dispensed by an appliance fixed to the mixer, which measures weight, volume or dosing time and is provided with a recorder. This appliance shall be accurately calibrated, and the calibration and dosage shall be checked at regular intervals or as directed by the PMC/EMPLOYER. All such admixtures shall be dispensed with the mixing water.

All admixture dispensers shall be thoroughly cleaned before commencing each day's work and at every interruption to the work.

Where admixtures are to be used in bulk form, these shall be weigh-batched as is provided in this Specification for the batching of cement.

Powder admixtures to be used in dose form shall only be allowed if premixed and used as solutions and then only if the premixing procedure has been previously approved by the PMC/EMPLOYER.

3.4.5.4 Corrosion Inhibitor

The use of proprietary corrosion inhibitors, whether specified or not, shall be subject to the written agreement of the PMC/EMPLOYER. Their prime function shall be to form a protective film on the reinforcing steel.

Proprietary corrosion inhibitors shall be added to the concrete in accordance with the recommendations of the manufacturer. The dosage and rate of application shall be established by the CONTRACTOR following consultation with the admixture manufacturer and shall be confirmed to the PMC/EMPLOYER in writing.

3.4.5.5 Chlorides

Under no circumstances shall calcium chloride or chloride-based admixtures be used in any concrete mix, grout or mortar. The chloride content of admixtures shall be independently tested in an approved laboratory for each batch of admixture before acceptance. Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted such as in mass concrete works, it shall be dissolved in water and added to the mixing water by an amount not exceeding 1.5% of the weight of the cement in each batch of concrete. The designed concrete mix shall be corrected accordingly.

3.5 SAMPLES AND TESTS

All materials used for the works shall be tested before use. The frequency of such confirmatory tests shall be decided by PMC/EMPLOYER.

Manufacturer's test certificate shall be furnished for each batch of cement/ reinforcing steel and when directed by PMC/EMPLOYER samples shall also be got tested by the CONTRACTOR in a laboratory approved by PMC/EMPLOYER at no extra cost to EMPLOYER. However, where material is supplied by EMPLOYER, all testing charges shall be borne by EMPLOYER, but transportation and preparation of material samples for the laboratory shall be done by CONTRACTOR at no extra cost.

Sampling and testing of aggregates shall be as per IS: 2386 under the supervision of PMC/EMPLOYER. The cost of all tests, sampling, etc. shall be borne by CONTRACTOR.

Water to be used shall be tested to comply with Clause 5.4 of IS: 456.

CONTRACTOR shall furnish manufacturer's test certificates and technical literature for the admixture proposed to be used. If directed, the admixture shall be got tested at an approved laboratory at no extra cost.

3.6 STORING OF MATERIALS

All material shall be stored in a manner to prevent its deterioration and contamination, which would preclude its use in the works. Requirements of IS: 4082 shall be complied with.

CONTRACTOR shall make his own arrangements for the storage of adequate quantity of cement even if cement is supplied by PMC/EMPLOYER. If such cement is not stored properly and has deteriorated, the material shall be rejected. Cost of such rejected cement, where cement is supplied by

PMC/EMPLOYER, shall be recovered at issue rate or open market rate whichever is higher. Cement bags shall be stored in dry weatherproof shed with a raised floor, well away from the outer walls and insulated from the floor to avoid moisture from ground. Not more than 15 bags shall be stacked in any tier. Storage arrangement shall be approved by PMC/EMPLOYER. Storage under tarpaulins shall not be permitted. Each consignment of cement shall be stored separately and consumed in its order of receipt. CONTRACTOR shall maintain record of receipt and consumption of cement.

Each size of coarse and fine aggregates shall be stacked separately and shall be protected from dropping leaves and contamination with foreign material. The stacks shall be on hard, clean, free draining bases, draining away from the concrete mixing area.

CONTRACTOR shall make his own arrangements for storing water at site in tanks of approved capacity. The tanks shall be cleaned at least once a week to prevent contamination.

The reinforcement shall be stacked on top of timber sleepers to avoid contact with ground/ water. Each type and size shall be stacked separately.

3.7 CONCRETE

3.7.1 GENERAL

Concrete grade shall be as designated on drawings. Concrete in the works shall be "DESIGN MIX CONCRETE" or "NOMINAL MIX CONCRETE". All concrete works of up to grade M15 shall be NOMINAL MIX CONCRETE whereas all other grades, M20 and above, shall be DESIGN MIX CONCRETE.

3.7.2 DESIGN MIX CONCRETE

For this specification, Design Mix Concrete is classified as "Normal Concrete". It shall be identified by a prefix and two numbers. Prefix "M" would denote Normal Concrete. The two numbers e.g. 25 - 40 would denote the crushing strength of cube at 28 days in N/mm² and maximum size of the coarse aggregates in millimeters respectively. Normal concrete shall have a net dry unit weight of not less than 25 kN/m³, for the finished structure after curing.

3.7.3 MIX DESIGN AND TESTING

For Design Mix Concrete, the mix shall be designed as per IS 10262 to provide the grade of concrete having the required workability and characteristic strength not less than appropriate values given in IS: 456. The design mix shall in addition be such that it is cohesive and does not segregate during placement and should result in a dense and durable concrete capable of giving the specified finish. For liquid retaining structures, the mix shall also result in watertight concrete. The CONTRACTOR shall exercise great care while designing the concrete mix and executing the works to achieve the desired result.

The minimum grade of concrete shall be as per Table 5 of IS: 456 for various exposure conditions of concrete. For various environmental conditions, refer to Table 3 of IS: 456.

The minimum cement content for Design Mix Concrete shall be as mentioned in the Schedule of Quantities.

The quantity of maximum mixing water per unit volume of concrete may be determined from Table 2 of IS 10262. The water content in Table 2 is for angular coarse aggregate and for 25 to 50 mm slump range. The water estimate in Table 2 can be reduced by approximately 10 kg for sub- angular aggregates, 20 kg for gravel with some crushed particles and 25 kg for rounded gravel to produce same workability. For the desired workability (other than 25 to 50 mm slump range), the required water content

may be established by trial or an increase by about 3 percent for every additional 25 mm slump or alternatively by use of chemical admixtures conforming to IS 9103. Water reducing admixtures or super plasticizing admixtures usually decrease water content by 5 to 10 percent and 20 percent and above respectively at appropriate dosages.

It shall be CONTRACTOR's sole responsibility to carry out the mix designs at his own cost. He shall furnish to PMC/EMPLOYER for approval at least 30 days before concreting operations, a statement of proportions proposed to be used for the various concrete mixes and the strength results obtained. The strength requirements of the concrete mixes ascertained on 150 mm cubes as per IS: 516 shall comply with the requirements of Table – 2 of IS: 456.

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested i.e., the sampling should be spread over the entire period of concreting and cover all mixing units. The minimum frequency of sampling of concrete of each grade shall be in accordance with the cl. 15.2 of IS 456.:

3 test specimens (cubes) shall be made for each sample for testing at 28 days. The test results of the sample shall be the average of the strength of 3 specimens.

In the 'very low' category of workability where strict control is necessary, for example pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate than slump (refer to IS: 1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (refer to IS: 9103).

Where single size graded coarse aggregate are not available, aggregates of different sizes shall be properly combined. The CONTRACTOR's mix design shall show that combined grading of coarse aggregate meets the requirements of Table 2 of IS: 383 for graded aggregates.

3.8 BATCHING AND MIXING OF CONCRETE

Proportions of aggregates and cement, as per approved concrete mix design, shall be by weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within $\pm 2\%$ for cement and $\pm 3\%$ for aggregate. The batching equipment shall be calibrated at the frequency decided by PMC/EMPLOYER.

Amount of water added shall be such as to produce dense concrete of required consistency, specified strength and satisfactory workability and shall be so adjusted to account for moisture content in the aggregates. Each time the work stops, the mixer shall be cleaned out, and while recommencing, the first batch shall have 10% additional sand and cement to allow for sticking in the drum.

Arrangement should be made by CONTRACTOR to have the cubes tested at his own expense in an approved laboratory or in field with prior consent of PMC/EMPLOYER. Sampling and testing of strength and workability of concrete shall be as per IS: 1199, IS: 516 and IS: 456. It is preferable to cast additional cubes (minimum 3 specimens) for testing at 7 days and 14 days.

3.9 READY MIXED CONCRETE

All specification as per IS: 4926 – "Specification for Ready Mixed Concrete" shall be applicable.

The design mix prepared by the RMC supplier shall be the responsibility of the CONTRACTOR. The testing of concrete as per Codal provisions and the specifications shall be done by the CONTRACTOR same as the normal concreting works.

3.10 PRECAST CONCRETE

3.10.1 GENERAL

Precast concrete shall comply with the preceding Sections relating to Concrete as far as they are applicable.

CONTRACTOR shall submit a method statement to PMC/EMPLOYER for approval, before any work is commenced on the manufacture, furnishing details of each stage of operation. The method statement shall inter alia include full details of the plant and equipment to be used and method and location of precast concrete manufacture, striking of shutters, curing, lifting, handling, storage, transportation and installation in the Works.

3.10.2 FORMWORK

The formwork shall be either steel or lined with steel, waterproof/ laminated board or such other material as directed and approved by the PMC/EMPLOYER. Forms shall be strongly constructed, closely jointed and smooth and shall be such as to ensure true sharp arises and a perfect surface. Forms shall be so designed that they can be taken apart and reassembled readily.

3.10.3 SURFACE FINISH

Surface Finish of precast units shall comply with requirements of this specification. The class of Finish shall generally be of F2 type unless detailed differently on the drawings or as directed by the PMC/EMPLOYER. No construction joints will be permitted within any precast work.

3.10.4 CASTING TOLERANCE

The casting tolerance, unless otherwise ordered or directed, shall be within +3 mm of true dimensions.

3.10.5 STRIKING FORMS

The method and time of striking the side shutters after casting the units will normally be left to the discretion of the CONTRACTOR, but the PMC/EMPLOYER may specify minimum time in which case the CONTRACTOR must comply with the PMC/EMPLOYER's directions. In the event of any damage resulting from premature removal of shutters, or from any other cause, the unit will be liable to rejection and replacement by the CONTRACTOR at his own cost, whether the PMC/EMPLOYER has specified a minimum striking time or not.

3.10.6 LIFTING, STACKING AND REMOVAL

Precast units shall not be lifted, transported or used in the Works until they are sufficiently mature. The crushing tests on the test cubes, which are to be kept along with the relevant precast units, will be used to assess the maturity of the units.

Lifting, stacking and removal of precast units shall be undertaken without causing shock, vibration or undue stress to or in the units. The CONTRACTOR shall satisfy the PMC/EMPLOYER that the methods he proposes for lifting, transporting and setting precast units will not overstress or damage the units in any way. In the event of overstress or damage due to whatever cause, the unit or units concerned will be liable to rejection. Rejected units shall be immediately broken up and removed from the site. The CONTRACTOR shall replace such rejected units at his own cost.

3.10.7 CURING

The top and sides of all precast units shall be kept covered constantly and in a damp condition with clean, potable fresh water for at least seven days after casting or for such further period as the PMC/EMPLOYER may direct. It is preferable to have a curing pond for this purpose.

3.10.8 PRECASTING RECORDS

The CONTRACTOR shall maintain records for each unit, which shall include the following:

- Type and reference number.
- Date of manufacture/ casting.
- Bed/ mould number.
- Curing method and duration.
- Date of removal from bed/ mould.
- Test Cube reference number and results.
- Date of placing in the Works.
- Location in the Works.

These records shall be in a format agreed by the PMC/EMPLOYER and shall always be available for inspection. Copies of these records shall be supplied to the PMC/EMPLOYER on completion.

3.11 **FORMWORK**

Formwork shall be all inclusive and shall consist of but not limited to shores, bracings, sides of footings, walls, beams and columns, bottom of slabs, etc. including ties, anchors, hangers, inserts, falsework, wedges, etc.

The Design and Engineering of the formwork as well as its construction shall be the responsibility of CONTRACTOR. However, if so, directed by PMC/EMPLOYER, the drawings and calculations for the design of the formwork shall be submitted to PMC/EMPLOYER for approval.

Formwork shall be designed to fulfil the following requirements:

Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits as given in clause 11.1 of IS 456.

The formwork may be of lined timber, waterproof/ plastic coated plywood, steel, plastic depending upon the type of finish specified. Sliding forms and slip form may be used with the approval of PMC/EMPLOYER. Timber for formwork shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps and other surface defects. Joints between formwork and formwork and between formwork and structure shall be sufficiently tight to prevent loss of slurry from concrete using foam and rubber seals.

The faces of formwork coming in contact with concrete shall be cleaned and two coats of approved mould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces, dust, etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

Forms intended for reuse shall be approved by the PMC/EMPLOYER. CONTRACTOR shall equip himself with enough quantity of shuttering to allow for wastage to complete the job in time.

Permanent formwork shall be checked for its durability and compatibility with adjoining concrete before it is used in the structure. It shall be properly anchored to the concrete.

For liquid retaining structures sleeves shall not be provided for through bolts nor shall through bolts be removed if provided. The bolts, in the latter case, shall be cut at 25 mm depth from the surface and the hole made good by cement mortar of the same proportion as the concrete just after striking the formwork.

Forms for substructure may be omitted when, in the opinion of PMC/EMPLOYER, the open excavation is firm enough (in hard non-porous soils) to act as a form. Such excavation shall be slightly larger, as directed by PMC/EMPLOYER, than that required as per drawing to compensate for irregularities in excavation.

Formwork showing excessive distortion, during any stage of construction, shall be removed. Placed concrete affected by faulty formwork, shall be entirely removed and formwork corrected prior to placement of new concrete at CONTRACTOR's cost.

The striking time for formwork shall be determined based on the following requirements:

- Development of adequate concrete strength;
- Permissible deflection at time of striking formwork;
- Curing procedure employed - its efficiency and effectiveness;
- Subsequent surface treatment to be done;
- Prevention of thermal cracking at re-entrant angles;
- Ambient temperatures and aggressiveness of the environment (unless immediate adequate steps are taken to prevent damage to the concrete).

Before removing formwork of soffit of slabs/ beams compressive strength at 7/ 14/ 21 days shall be checked.

Under normal circumstances (generally where temperatures are above 200 Celsius) forms may be struck after expiry of the period given in IS: 456 unless directed otherwise by PMC/EMPLOYER. It is the CONTRACTOR's responsibility to ensure that forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resists surface damage and any stresses arising during the construction period.

3.12 REINFORCEMENT FABRICATION AND PLACEMENT

3.12.1 Reinforcing bars shall be bent and fixed in accordance with the procedure specified in IS 2502.

3.12.2 All bars shall be bent by Bar bending machines.

3.12.3 Re-bending or straightening incorrectly bent bars shall not be done without approval of PMC/EMPLOYER.

- 3.12.4 Reinforcement shall be accurately fixed and maintained firmly in the correct position using blocks, spacers, chairs, binding wire, etc. to prevent displacement during placing and compaction of concrete in accordance with clause 12.3 to 12.6 of IS 456. The tied in-place reinforcement shall be approved by PMC/EMPLOYER prior to concrete placement. PVC or concrete spacers of appropriate size shall be used with the approval of PMC/EMPLOYER.
- 3.12.5 Binding wire shall be 18-gauge soft annealed wire. Ends of the binding wire shall be bent away from the concrete surface and in no case encroach into the concrete cover.
- 3.12.6 Substitution of reinforcement, laps/ splices not shown on drawing shall be proposed by CONTRACTOR at his own cost and approved by PMC/EMPLOYER.
- 3.12.7 If permitted by PMC/EMPLOYER, welding of reinforcement shall be done in accordance with IS: 2751, IS: 9417 and SP: 34 as applicable.
- 3.12.8 Tolerance on placement of reinforcement shall be as per Cl. 12.3 of IS: 456.

3.13 TOLERANCES

Tolerance for formed and concrete dimensions shall be as per IS: 456 unless specified otherwise. Tolerance is a specified permissible variation from lines, grade or dimensions given in drawings. No tolerance specified for horizontal or vertical building lines or footings shall be construed to permit encroachment beyond the legal boundaries. Unless otherwise specified, the following tolerances will be permitted.

3.13.1 TOLERANCES FOR RC BUILDINGS

3.13.1.1 Variation from the Plumb

	In the lines and surfaces of columns, piers, walls and in arises 5 mm per 2.5 m or 25 mm, whichever is less.		
	For exposed corner columns and other conspicuous lines.		
	In any bay or 5 m maximum	-	5 mm
	In 10 m or more	-	10 mm

3.13.1.2 Variation from the level or from the grades indicated on the drawings

	In slab soffits, ceilings, beam soffits and in arises		
	In 2.5 m	-	5 mm
	In any bay or 5 m maximum	-	10 mm
	In 10 m or more	-	15 mm
	For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines		
	In any bay or 5 m maximum	-	5 mm
	In 10 m or more	-	15 mm

3.13.1.3 Variation of the linear building lines from established position in plan and related position of columns, wall and partitions

In any bay or 5 m maximum	-	10 mm
In 10 m or more	-	20 mm

3.13.1.4 Variation in the sizes and locations of sleeves, openings in walls and floors - 5 mm except in the case of and for anchor bolts.

3.13.1.5 Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus	-	5 mm
Plus	-	10 mm

3.13.1.6 Footings

	Variation in dimension in plan		
	Minus	-	5 mm
	Plus	-	50 mm
	Misplacement or eccentricity		
	2% of footing width in the direction of misplacement but not more than 50 mm		
	Reduction in thickness		
	Minus	-	5% of specified thickness subject to a maximum of 50 mm

3.13.1.7 Variation in steps

	In a flight of stairs		
	Rise	-	3 mm
	Tread	-	5 mm
	In consecutive steps		
	Rise	-	1.5 mm
	Tread	-	3 mm

3.13.2 TOLERANCES IN OTHER STRUCTURES

3.13.2.1 All structures

	Variation of the construction linear outline from established position in plan.		
	In 5 m	-	10 mm
	In 10 m or more	-	15 mm
	Variation of dimensions to individual structure features from established positions.		
	In 20 m or more	-	25 mm
	In buried construction	-	50 mm

.	Variations from plumb, from specified batter or from curved surfaces of all structures.		
	In 2.5 m	-	10 mm
	In 5 m	-	15 mm
	In 10 m or more	-	25 mm
	In buried construction	-	Twice the above values
.	Variations from level or grade indicated on drawings in slabs, beams, soffits, horizontal grooves and visible arises.		
	In 2.5 m	-	5 mm
	In 7.5 m or more	-	10 mm
	In buried construction	-	Twice the above values
.	Variation in cross-sectional dimensions of columns, beams, buttresses, piers and similar members.		
	Minus	-	5 mm
	Plus	-	10 mm
.	Variation in the thickness of slabs, walls, arch sections and similar members.		
	Minus	-	5 mm
	Plus	-	50 mm

3.13.2.2 Footing for Columns, Piers, Walls, Buttresses and Similar Members

.	Variation of dimension in Plan		
	Minus	-	10 mm
	Plus	-	50 mm
.	Misplacement or eccentricity		
	2% footing width in the direction of misplacement but not more than 50 mm		
.	Reduction in thickness		
	5% of specified thickness subject to a maximum of 50 mm		

3.13.3 TOLERANCE IN FIXING ANCHOR BOLTS

.	Anchor bolts without sleeves	:	1.5 mm in plan
	Anchor bolts with sleeves	:	5.0 mm in elevation
	for bolts up to and including 28 mm dia.	:	5 mm in all directions
	for bolts up to 32 mm dia.	:	3 mm in all directions
.	Embedded parts	:	5 mm in all directions

3.13.4 TOLERANCES IN FORMWORK

The formwork shall be designed and constructed to the shapes, lines and dimensions shown on the drawings within the tolerances given below:

1.	Deviation from specified dimensions of cross section of columns and beams	-6 mm
2.	Deviations from dimensions of footings (tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel or dowels)	+12 mm
a)	Dimension in Plan	-12 mm +50 mm
b)	Eccentricity	0.02 times the width of the footing in the direction of deviation, but not more than 50 mm
c)	Thickness	± 0.05 times the specified thickness

3.13.5 Tolerance for top of concrete of equipment and structural steel foundations shall be as under unless more stringent requirements are specified by equipment manufacturer:

- Where grout thickness is less than or equal to 25 mm: ±5 mm.
- Where grout thickness is more than 25 mm: ±5 mm.

3.14 EXECUTION AND REMOVAL OF FORMS

Before placing concrete, the surface of all forms shall be coated with suitable non-staining form releasing agents such as raw linseed oil to prevent adhesion of concrete and to facilitate removal of forms.

The form releasing agent shall cover the forms fully and evenly without excess over drip. Care shall be taken to prevent form releasing agents from getting on the surface of the construction joints and on reinforcement bars. Special care shall be taken to thoroughly cover form strips for narrow grooves, to prevent swelling of the forms and the consequent damage to concrete prior to or during removal of forms.

Immediately before concrete is placed care shall be taken to see that all forms are in proper alignment and the supports and fixtures are properly secured and tightened.

Where forms for continuous surfaces are placed in successive units, the forms shall lap and fit tightly over the completed surface to prevent leakage of cement slurry from the fresh concrete and to maintain accurate alignment of the surface.

Forms shall be left in place until their removal is authorised and shall then be removed with care to avoid injury to concrete.

Removal of forms shall be started when the concrete has achieved strength of at least twice the stress to which the concrete may be subjected at the time of removal of formwork.

In normal circumstances and where ordinary Portland cement is used forms can be allowed to be struck as per the guideline given in clause 11.3 of IS 456.

Note: Time shall be measured from last batch concreted in respect to the structural member under consideration. For other cement stripping time as recommended above may be suitably decided by PMC/EMPLOYER.

Re-propping shall be done to the below floor to carry the construction load transferred through props/ equipment, etc. during construction of upper floor and props left under till the period of removal of props supported to or any other load due to construction load on the upper floor. Re-propping shall be part of shuttering/ formwork for concrete without any claim for extra cost.

3.15 SETTLEMENT OF FORMWORK AND CAMBER

Due to various reasons such as closure of form joints, shrinkage of timber, dead load deflections, elastic shortening of form members or formwork, deflections, settlement may occur. The CONTRACTOR shall take precautions, including using adequately rigid formwork, to prevent excessive settlement/ deflection; the usual acceptable limit being 1/500 of the spans of the formwork.

In the absence of any specified camber on the drawings, soffit of all beams more than 5 m in span and other than pre-stressed concrete beams shall be laid to a camber, the amount of which at mid span shall not be less than 1/500 of the span of the structure. The profile of soffit shall be parabolic.

3.16 PREPARATION PRIOR TO CONCRETE PLACEMENT

The faces of formwork coming in contact with concrete shall be cleaned and two coats of approved mould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces, dust, etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

All arrangements - formwork, equipment and proposed procedure, shall be approved by PMC/EMPLOYER. CONTRACTOR shall maintain separate Pour Card for each pour.

3.17 TRANSPORTING, PLACING AND COMPACTING CONCRETE

Concrete shall be transported from the mixing plant to the formwork with minimum time lapse by methods that shall maintain the required workability and will prevent segregation, loss of any ingredients or ingress of foreign matter or water.

In all cases concrete shall be deposited as nearly as practicable directly in its final position. For locations where, direct placement is not possible and in narrow forms, CONTRACTOR shall provide suitable drops and "Elephant Trunks". Concrete shall not be dropped from a height of more than 1.5 m.

Concrete shall not be placed in flowing water. Under water concrete shall be placed in position by tremie or by pipeline from the mixer and shall never be allowed to fall freely through the water.

While placing concrete the CONTRACTOR shall proceed as specified below and ensure the following:

- Continuously between construction joints and predetermined abutments.
- Without disturbance to forms or reinforcement.
- Without disturbance to embedment.
- Without dropping in a manner that could cause segregation or shock.
- In deep pours only when the concrete and formwork is designed for this purpose and by using suitable chutes or pipes.
- Do not place if the workability is such that full compaction cannot be achieved.

- Without disturbing the unsupported sides of excavations; prevent contamination of concrete with earth. Provide sheeting, if necessary. In supported excavations, withdraw the linings progressively as concrete is placed.
- If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.
- Ensure that there is no damage or displacement to sheet membranes.
- Record the time and location of placing structural concrete.
- When concrete is brought from batching plant to site in millers, the time of mixing and the time of pour shall be checked to ensure that setting has not started.

Concrete shall normally be poured & compacted in its final position within initial setting time. Concrete shall be compacted during placing with approved vibrating equipment without causing segregation until it forms a solid mass free from voids, thoroughly worked around reinforcement and embedded fixtures and into all corners of the formwork. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers. Vibrators shall not be allowed to come in contact with reinforcement, formwork and finished surfaces after start of initial set. Over-vibration leads to segregation and shall be avoided.

Concrete may be conveyed and placed by mechanically operated equipment after getting the complete procedure approved by PMC/EMPLOYER. The slump shall be held to the minimum necessary for conveying concrete by this method. When concrete is to be pumped, the concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

CONTRACTOR shall submit a method statement to PMC/EMPLOYER for approval, furnishing details of pour sequence, thickness of each layer, mixing and conveying equipment proposed, etc. preferably with a sketch.

Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for at least 24 hours after the final set of concrete before the start of subsequent placement. Placing shall stop when concrete reaches the top of the opening in walls or bottom surface of slab, in slab and beam construction, and it shall be resumed before concrete takes initial set but not until it has had time to settle as determined by PMC/EMPLOYER. Concrete shall be protected against damage until final acceptance.

3.18 PLACING OF CONCRETE BY PUMPING METHODS

3.18.1 GENERAL

Placing of concrete by pumping will be as specified or authorised by PMC/EMPLOYER to achieve the required speediness of construction and maintain targeted schedules.

Pumping of concrete shall be done only after conducting pumpability trials to ascertain the performance of fresh concrete on pumping in presence of the PMC/EMPLOYER as per approved procedure. During pumping, concrete shall be conveyed either through rigid pipe or through flexible hose and discharged directly into the desired area. A steady supply of pumpable concrete is necessary for satisfactory pumping. Pumpable concrete requires properly graded aggregates, material uniformity, consistent batching and thorough mixing. They shall be used for concreting densely reinforced structures, internal structural elements of buildings and for large pours of concrete. Concrete pumps used shall be able to deliver concrete over a horizontal and vertical distance as per the directives of the PMC/EMPLOYER.

Placement of normal concrete by pumping will be permitted as specified or authorised by the PMC/EMPLOYER. The decision, whether to pump any mix shall rest entirely with the PMC/EMPLOYER

and no extra claims for payment on this account will be entertained. The pumping equipment, pipe lines and accessories as well as proportioning of pumpable concrete shall generally conform to the recommendations of ACI-304.2R (latest revision) – Placing of concrete by pumping method - Proportioning of pumpable mixes gives certain guide lines on concrete mix. However, final selection of mix shall be as instructed by the PMC/EMPLOYER.

3.18.2 PUMPING EQUIPMENT

Requisite number of modern dependable concrete pumps capable of pumping concrete of specified quality at a rate required to meet the construction schedules, together with a balanced complement of pipelines, accessories, spare parts, power-controlled placing booms, and experienced pump operators and maintenance staff shall be provided at locations and in a manner approved by the PMC/EMPLOYER.

The pumping plant shall be completely installed on each occasion, with preliminary mock operation for a sufficient length of time prior to scheduled placement of a concrete pour, to enable the PMC/EMPLOYER to conduct pumpability tests and necessary adjustments for the concrete mix, prior to use of the pumping for placement of concrete.

3.18.3 PROPORTIONING PUMPABLE CONCRETE

Basic Consideration

- a. Although the ingredients of concrete to be placed both by pumping and by other means are the same, more emphasis shall be laid on the quality control and proportioning of a dependable pumpable mix. Dependability is ensured by the equipment and the operator, with the control of all the ingredients in the mixture, the batching and mixing operations, and the knowledge and experience of all the personnel from beginning to end.
- b. Concrete mixes for pumping shall be “plastic” at all times. Stiff mixes shall not be used for pumping as they do not pump well. Attention shall be given to the mortar (cement, sand and water) and the amounts and sizes of coarse aggregates.

3.18.4 TESTING FOR PUMPABILITY

No mix shall be accepted for use on a pumping job until an actual test under field condition has been completed. Testing a mix for pumpability involves duplication of the anticipated job condition from beginning to end. The batching and conveying by truck mixers shall be the same as will be used, the same pump and operator shall be present. The pipe and hose layouts shall simulate the actual condition as far as practicable. Prior use of a mix on another job may furnish evidence of pumpability, but only if conditions are duplicated. Before commencing a new concreting job, the CONTRACTOR shall carry out pumpability tests in consultation with the PMC/EMPLOYER. Concrete used in such tests shall not be used in the actual construction, unless specifically permitted by the PMC/EMPLOYER.

Following parameters shall be established by pumpability trials:

- In-situ compressive and split tensile strength of concrete.
- Curing the sample at Site by sprinkling water.
- Curing the sample at Laboratory in curing tanks.
- Wet sieve analysis of concrete to ensure that proportions of ingredients before and after pumping are same.

3.18.5 FIELD PRACTICES

Proper planning of concrete supply, pump location, line layout, placing sequence and the entire pumping operation shall be done by the CONTRACTOR and got approved by the PMC/EMPLOYER on every occasion before commencement of concreting job. The pump shall be as near the placing area as practicable, and the entire surrounding area must have adequate bearing strength to support the concrete delivery trucks, thus assuring a continuous supply of concrete. For important concrete placements and large jobs, adequate standby power and pumping equipment shall be provided as replacement, should break down occur.

Direct communication shall be maintained between the pump operator, concrete placing crew and batching plant. The placing rate shall be estimated so that concrete can be operated at an appropriate delivery rate. As a final check, the pump shall be started and operated without concrete to ascertain that, all moving parts are operating properly. As stated previously, the grout mortar shall be pumped into the line to provide initial lubrication for the concrete. As soon as concrete is received, the pump shall be run slowly until the lines are completely full and the concrete is slowly moving. Once the pumping is started, the operator shall ensure that the hopper of the pump is not emptied beyond a certain level, as air may enter the pipeline and cause choking. Continuous pumping should be ensured. If a delay occurs because of concrete delivery, form repairs, or other factors, the pump shall be slowed down to maintain some movement of the concrete till normal supply is resumed. For longer delays, the concrete in the receiving hopper shall be made to last as long as possible by moving the concrete in the lines occasionally with one stroke of the pump. In confined areas, attempt shall be made by the CONTRACTOR to run a return line back to the pump, so that concrete can be re-circulated during delays.

The CONTRACTOR shall ensure that obstructions are not found in the pipe due to interruption in the feed of the concrete by more than 30 to 45 minutes.

Minor blockages shall be cleared by operating a few strokes of the pump in reverse momentarily and then by returning to normal forward pumping. If this fails, a succession of reverse and forward strokes shall be carried out to remove the blockage. Should this fail also, the blockage may be due to air-lock and the entrapped air must be removed.

Attempt to push through the obstructions by repeatedly starting the pump will result in compaction of the concrete and complicate the removal of the concrete in the pipe. Blockages in the pipe are usually discovered by the sound when the pipe is struck. To remove the obstruction, the concrete pipe shall be taken apart at the assured position and cleaned. Then the pumping process shall be started all over again.

This method of checking the blockage and setting it right shall be done with great speed as excessive delay will cause setting of concrete in the pipeline downstream of the choke and will lead to further blockage. When the blockage is being found out and remedied, the pump shall periodically be given one or two strokes forward to keep the concrete in motion. If blockage occurs in the placer boom, a pipe joint near the base of the placer boom shall be opened and the boom made vertical to drain the pipeline by gravity.

Cleaning blockages are time consuming and as such major blockages shall best be avoided by ensuring a pumpable mix. Concrete that is either under or over sanded, short of fines, gap graded, has an excess of a size, or excessively wet or dry will be rejected by the pump either by blockage or by hard pumping involving excessive pressures.

The termination of pumping operations shall be carefully planned to utilise the concrete dormant in the pipeline and the hopper when the pump is stopped and to avoid wastage.

When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped, and a go-devil be inserted and forced through the line to clear it out. Water under pressure shall be used to push the go-devil. The go-devil shall be stopped about one metre from the end of the line, so that the water in the line will not spill over into the placement area. After flushing, water in the pipe shall be removed by drain cock which shall be located for this purpose in the lowest part of the line. After all concrete has been removed from the lines, all lines and equipment shall be immediately cleaned thoroughly.

3.18.6 QUALITY CONTROL

CONTRACTOR shall ensure that workmanship and plant shall be maintained at peak efficiency. Degree of control on all the concrete operation from selection of the ingredients to the final testing of specimen shall be in line with the assumptions made in mix design with respect to the standard deviation and coefficient of variation.

The CONTRACTOR shall ensure that any compromise in quality is not done for the pumped concrete. To be pumpable, a high level of quality control for the assurance of uniformity must be maintained. Sampling at both the truck discharges and point of final placement shall be done by the CONTRACTOR and the PMC/EMPLOYER jointly, as frequently as the PMC/EMPLOYER desires to determine, if any change in the slump air content, and other significant mix characteristics occur take necessary corrective actions.

The CONTRACTOR shall engage experienced supervision at all levels. The placing crew shall be experienced and qualified and each operation shall be well planned and properly scheduled.

All the crew engaged in each of the concrete activities shall demonstrate in the presence of the PMC/EMPLOYER, their skills and capabilities to produce the final product as specified.

3.19 MASS CONCRETE WORKS

Sequence of pouring for mass concrete works shall be as approved by PMC/EMPLOYER. CONTRACTOR shall exercise great care to prevent shrinkage cracks and shall monitor the temperature of the placed concrete if directed.

3.20 PLACING TEMPERATURE OF CONCRETE

Placing temperature of concrete should be maintained as specified in Schedule of Quantities or as directed by PMC/EMPLOYER, to avoid shrinkage cracking.

Mixing water shall be kept cool by storing it under cover. Chilled water or crushed ice as part of the mixing water to achieve the specified placing temperature shall be used. For chilled water, it is recommended that the CONTRACTOR install and maintain refrigeration facility of required capacity. The CONTRACTOR shall also build and maintain well insulated adequate capacity storage tank for cold water with insulated connected piping. To supplement this refrigeration facility, the CONTRACTOR will have to have ice plant or use commercial ice subject to approval of the PMC/EMPLOYER. The full quantity of crushed ice shall be stored in cold storage 24 hours in advance of the start of concreting. The temperature in cold storage shall not be more than -20 C. The CONTRACTOR should study the placing temperature condition and work out plant capacity commensurate with the construction schedule requirements and submit his scheme along with the tender.

Ice when used as replacement for a portion or all the mixing water shall be produced from water, which meets the requirements of clause 3.4.3. Ice when used shall be in flakes of size 3 mm or below or crushed condition and the crushed ice shall be such as to pass completely, 10 mm sieve.

3.21 CURING

Curing and protection shall start immediately after the compaction of the concrete to protect it from:

- Premature drying out, particularly by solar radiation and wind;
- Leaching out by rain and flowing water;
- Rapid cooling during the first few days after placing;
- High internal thermal gradients;
- Low temperature or frost;
- Vibration and impact, which may disrupt the concrete and interfere with its bond to the reinforcement.

All concrete, unless directed otherwise by PMC/EMPLOYER, shall be cured as specified in clause 13.5 of IS 456. The quality of curing water shall be the same as that used for mixing.

Where a curing membrane is directed to be used by the PMC/EMPLOYER, the same shall be of a non-wax base and shall not impair the concrete finish in any manner. The curing compound to be used shall be got approved from the PMC/EMPLOYER before use and shall be applied with spraying equipment capable of a smooth, even textured coat.

Curing may also be done by covering the surface with an impermeable material such as polyethylene, which shall be well sealed and fastened.

Extra precautions shall be exercised in curing concrete during cold and hot weather as per clause no. 8.3 of IS: 7861 (Part II) and clause no. 8.2 of IS: 7861 (Part I) respectively.

Curing arrangement shall be subjected to PMC/EMPLOYER's approval.

3.22 CONSTRUCTION JOINTS AND KEYS

Construction joints (location and type) shall be as shown on the drawing or as approved by PMC/EMPLOYER. Concrete shall be placed without interruption until completion of work between construction joints. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made with the approval of PMC/EMPLOYER.

Dowels for concrete work, not likely to be taken up soon, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as directed by PMC/EMPLOYER.

Before resuming concreting on a surface, which has hardened all laitance and loose aggregates shall be thoroughly removed by wire brushing and/ or hacking, the surface washed with high pressure water jet and treated with thin layer of cement slurry for vertical joints and a 15 mm thick layer of cement sand mortar for horizontal joints, the ratio of cement and sand being the same as in the concrete mix.

3.22.1 CONSTRUCTION JOINT TREATMENT

Methodology stated herein under must be followed by CONTRACTOR wherever instructed by the PMC/EMPLOYER at no additional cost to the EMPLOYER.

The entire construction joint shall be treated by green cutting using air/ water jet at suitable pressure to remove the laitance from the green concrete surface to receive subsequent pour over it. Suitable,

approved brand of surface retarder shall be used to retard the setting time of green concrete to a depth of 5 to 8 mm. Green cutting shall be done only after the final setting of concrete, so that the additional water available from the air water jet used for green cutting on the surface does not harm the quality of the concrete.

3.22.2 APPLICATION OF SURFACE RETARDER AND GREEN CUTTING AT CONSTRUCTION JOINT OF CONCRETE

3.22.2.1 Scope

Work under this procedure covers application of surface retarder over the green concrete and green cutting the exposed surface of concrete after final setting time to expose the aggregate, for proper bonding with fresh concrete of successive pours.

3.22.2.2 Material Qualification

The surface retarder shall be qualified for use based on number of site trials/ mock-ups for achieving the desired surface after green cutting during different ambient conditions

3.22.2.3 Application

Surface retarder shall be applied uniformly with the help of agricultural spray machine at the rate of 5 to 6 sqm/litre. Form panel at construction joint: Wherever the side of a pour is to receive concrete later, a bulk head of such sides will be coated with surface retarder at least one hour before the receipt of concrete.

For horizontal construction joints: Wherever the concrete is to be placed above a pour, surface retarder shall be applied on the finished top surface of the said pour within half an hour of finishing.

3.22.2.4 Green Cutting

Green cutting shall be started after final setting time of concrete to expose the aggregate, for proper bonding with fresh concrete of successive pours. The surface of concrete shall be green cut using air-water jet. Bunds shall be made using cement mortar at convenient locations and cut out shall be made in the side shutter to drain off excess water. All the laitance and green cut material shall be removed from the green cut surface simultaneously.

The time of green cutting shall be displayed on Tags, which will be placed at appropriate locations so that said activity can be controlled in the proper way.

When concreting is to be resumed on a surface, which has not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed, and a coat of cement slurry applied. On this a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old work. Thereafter work shall proceed in the normal way.

Approved epoxy Bonding agent, for bond between old (say 28 days or more) and new concrete may also be used as per manufacturer's specifications.

3.23 FOUNDATION BEDDING

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or spongy area shall be cleaned out and back filled with either soil-cement mixture, lean concrete or clean sand compacted as directed by PMC/EMPLOYER. The surfaces of absorptive soils shall be moistened.

Concrete shall not be deposited on large sloping rock surfaces. The rock shall be cut to form rough steps or benches by picking, barring or wedging. The rock surface shall be kept wet for 2 to 4 hours before concreting.

3.24 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

Immediately after the shuttering is removed, all the defective areas such as honeycombed surfaces, rough patches, etc. shall be brought to the notice of PMC/EMPLOYER who may permit patching of the defective areas or reject the concrete work. PMC/EMPLOYER's decision on rejection of concrete work shall be final.

All through holes for shuttering shall be filled with cement mortar for full depth and neatly plugged flush with surface.

Rejected concrete shall be removed and replaced by CONTRACTOR at no additional cost to PMC/EMPLOYER's

For patching of defective areas all loose materials shall be removed, and the surface shall be prepared by cleaning by compressed air or water jetting.

Bonding between hardened and fresh concrete shall be done either by placing cement mortar or by applying epoxy. The decision of the PMC/EMPLOYER as to be the method of repairs to be adopted shall be final and binding on the CONTRACTOR and no extra claim shall be entertained on this account. The surface shall be saturated with water for 24 hours before patching is done with 1:5 cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as directed by PMC/EMPLOYER.

CONTRACTOR shall submit a method statement for such repairs to PMC/EMPLOYER for approval.

3.25 HOT WEATHER REQUIREMENT

Concreting during hot weather shall be carried out as per IS: 7861 (Part I).

Adequate provisions shall be made to lower concrete temperatures, which shall not exceed 400 C at the time of placement of fresh concrete.

Where directed by PMC/EMPLOYER, CONTRACTOR shall spray non-wax based curing compound on unformed concrete surface at no extra costs.

3.26 COLD WEATHER REQUIRMENTS

Concreting during cold weather shall be carried out as per IS: 7861 (Part 2).

The ambient temperature during placement and up to final set shall not fall below 50 C. Approved anti-freeze/ accelerating additive shall be used where directed.

For major and large-scale concreting works the temperature of concrete at times of mixing and placing, the thermal conductivity of the formwork and its insulation and stripping period shall be closely monitored.

3.27 LIQUID RETAINING STRUCTURES

The CONTRACTOR shall take special care for concrete of liquid retaining structures, underground structures and those other specifically called for to guarantee the finish and water tightness.

The minimum level of surface finish for liquid retaining structures shall be of smooth type. All such structures shall be hydro-tested.

The CONTRACTOR shall include in his price hydro-testing of structure, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipe lines, etc.

Any temporary arrangements that may have to be made to ensure stability of the structures shall also be considered to have been considered while quoting the rates.

Any leakage/ sweating that may occur during the hydro-test or subsequently during the defect liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/

epoxy pressure grouting, guniting or such other method as may be approved by the PMC/EMPLOYER. All such rectification shall be done by the CONTRACTOR to the entire satisfaction of the PMC/EMPLOYER at no extra cost to the EMPLOYER.

3.28 HYDRO TESTING CONCRETE STRUCTURES

Hydrostatic test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by PMC/EMPLOYER, as described below:

In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven-day period for absorption after filling with water. In the case of structures whose external faces are submerged and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hours over period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure. The PMC/EMPLOYER shall decide on the actual permissible nature of this drop in the surface level, considering whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Each compartment/ segment of the structure shall be tested individually and then all together.

For structures such as pipes, tunnels, etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

3.29 OPTIONAL TESTS

If PMC/EMPLOYER feels that the materials i.e. cement, sand, coarse aggregates, reinforcement and water are not in accordance with the specifications or if specified concrete strengths are not obtained, he may order tests to be carried out on these materials in laboratory, to be approved by the PROJECT OFFICER, as per relevant IS Codes. EMPLOYER shall pay only for the testing of material supplied by the EMPLOYER, otherwise CONTRACTOR shall have to pay for the tests. Transporting of all material to the laboratory shall however be done by the CONTRACTOR at no extra cost to EMPLOYER.

In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes do not give the stipulated strength, PMC/EMPLOYER reserves the right to order the CONTRACTOR to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, as per relevant IS specifications. All these tests shall be carried out by CONTRACTOR at no extra cost to the EMPLOYER. Alternately PMC/EMPLOYER also reserves the right to ask the CONTRACTOR to dismantle and re-do such unacceptable work at the cost of CONTRACTOR.

If the structure is certified by PROJECT OFFICER/ PMC as having failed, the cost of the test and subsequent dismantling/ reconstruction shall be borne by CONTRACTOR.

The quoted unit rates/ prices of concrete shall deem to provide for all tests mentioned above.

In case of doubt regarding the grade of concrete used, either due to poor workmanship or based on cube strength results, Non-Destructive Tests (NDT) shall be carried out to ascertain the strength of the concrete as per the technical specification attached in the tender document.

3.30 QUALITY CONTROL

CONTRACTOR shall adopt the Quality Control format provided by the PMC/EMPLOYER. A copy of formats shall be furnished to CONTRACTOR by PMC/EMPLOYER/ EMPLOYER after the contract is awarded.

Alternatively, if CONTRACTOR has his own QC formats he may adopt them subjected to such modifications considered necessary by PMC/EMPLOYER.

In either case CONTRACTOR shall submit his detailed Quality Assurance Plan along with the bid. This would be reviewed, appropriately modified and approved by CONSULTANT/ PMC/EMPLOYER after the award of contract.

3.31 INSPECTION

All materials, workmanship and finished construction shall be subject to continuous inspection and approval of PMC/EMPLOYER. Materials rejected by PMC/EMPLOYER shall be expressly removed from site within 3 working days and shall be replaced by CONTRACTOR immediately at no extra cost to EMPLOYER.

3.32 CLEAN-UP

Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris, scraps of wood, etc. resulting from the work shall be removed and the premises left clean.

3.33 ACCEPTANCE CRITERIA DURING CONSTRUCTION STAGE AND HARDENED STATE

Any concrete work shall satisfy the requirements given below individually and collectively for it to be acceptable.

- Properties of constituent materials;
- Characteristic compressive strength;
- Specified mix proportions;
- Minimum cement content;
- Maximum free-water/cement ratio;
- Workability;
- Temperature of fresh concrete, if specified.;
- Density of fully compacted concrete, if specified;
- Cover to embedded steel;
- Curing;
- Tolerances in dimensions;
- Tolerances in levels;
- Surface finishes;

PMC/EMPLOYER's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the CONTRACTOR.

For work not accepted, PMC/EMPLOYER may review and decide whether remedial measures are feasible to render the work acceptable. PMC/EMPLOYER shall in that case direct the CONTRACTOR to undertake the remedial measures. These shall be expeditiously and effectively implemented by CONTRACTOR. Nothing extra shall become payable to CONTRACTOR by EMPLOYER for executing remedial measures.

3.34 MODE OF MEASUREMENT AND PAYMENT

The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment because of such items and leaving holes, embedding inserts, etc. shall be entertained unless

separately provided for in the Schedule of Quantities. No extra claim shall also be entertained due to change in the number, position and/ or dimensions of holes, slots or openings, sleeves, inserts or on account of any increased lift, lead of scaffolding, etc. All these factors shall be taken into consideration while quoting the unit rates. Unless provided for in the Schedule of Quantities the rates shall also include fixing inserts in all concrete work, whenever required.

Payments for concrete will be made based on unit rates quoted for the respective items in the Schedule of Quantities.

Payment for beams will be made for the quantity based on the depth being reckoned from the underside of the slabs and length measured as the clear distance between supports. Payment for columns shall be made for the quantity based on height reckoned up to the underside of slabs.

The unit rate for precast concrete members shall include formwork, mouldings, finishing, hoisting and setting in position including setting mortar, provision of lifting arrangement, etc. complete. Reinforcement and inserts shall be measured and paid for separately under respective item rates.

Only the actual quantity of steel embedded in concrete including laps as shown on drawings or as approved by PMC/EMPLOYER shall be measured and paid for, irrespective of the level or height at which the work is done. The unit rate for reinforcement shall include all wastage, binding wires, chairs, spacer bars, etc. for which no separate payment shall be made.

Where the formwork is paid for separately, it shall be very clearly understood that payment for formwork is inclusive of formwork, shuttering, shoring, propping, scaffolding, de-shuttering, etc. complete. Only the net area of concrete formed (shuttered) shall be measured for payment.

Where reinforcement is supplied by EMPLOYER, the quantity of chairs and spacer bars shall be measured for accounting wastage only.

Cost of Admixtures shall be deemed to be included in the rates and no separate payment shall be made.

4 TERMITE PRECONSTRUCTIONAL CHEMICAL TREATMENT IN BUILDINGS**4.1 SCOPE**

This specification covers the general requirements for Anti-termite Constructional Measures, chemical treatment of soils for the protection of buildings from attack by subterranean termites, chemicals to be used with their minimum rates of application and procedure to be followed while the building is under construction.

4.2 APPLICABLE CODES AND SPECIFICATIONS

The following codes, standards and specifications are made a part of this specification. In case of discrepancy between this specification and those referred to herein, this specification shall govern.

The codes and standards mentioned below shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the PMC/EMPLOYER in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. PMC/EMPLOYER may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

1	IS 6313 Part 1: 1981 (R2015)	Code of practice for anti-termite measures in buildings: Part 1 Constructional measures
2	IS 6313 Part 2: 2013 (R2018)	Code of Practice for Anti-Termite Measures in Buildings - Part 2: Pre-Constructional Chemical Treatment Measures
3	IS 6313 Part 3: 2013 (R2018)	Code of Practice for Anti-termite Measures in Buildings - Part 3: Treatment for Existing Buildings
3	IS:8944-2005	Specification for Chlorpyrifos Emusifiable Concentrates
4	IS:16131-2015	Specification for imidacloprid suspension concentrate
5	IS:4015-1998	Guide for Handling cases of Pesticide Poisoning

4.3 GENERAL

Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials, any temporary works, consumables, any and everything necessary whether such items are specifically stated herein for completion of the job in accordance with specification requirements or not.

All work shall be done in the order of progress required by PMC/EMPLOYER's construction programme. Contractor shall take all necessary precautions to prevent any accident in connection with the performance of the work.

On completion of all work, Contractor shall leave the entire premises within the site of his operation clean and free from all rubbish resulting from his operation.

PMC/EMPLOYER reserves the right to inspect, check and direct any or all operations at any stage of the work and to require unsatisfactory work to be remedied at Contractor's expense.

No work shall be carried out under unsuitable weather conditions viz. when raining or when the soil is wet due to rain or sub-soil water.

Chemicals shall be brought to site of work in sealed original containers. The materials shall be brought in, at a time, in adequate quantity to suffice for the work. The material shall be kept in cool and locked stores. The empties shall not be removed from the work site till the relevant item of work has been completed and permission granted by PMC/EMPLOYER.

Chemicals available in concentrated forms with concentration indicated on the sealed containers only shall be used. Chemicals shall be diluted with water in required quantity before use, using graduated containers to achieve the desired percentage of concentration:

4.4 PRE-CONSTRUCTIONAL CHEMICAL TREATMENT

4.4.1 APPLICATION

Hand operated pressure pump with graduated containers shall be used to ensure uniform spraying of the chemical. Continuous check shall be kept ensuring that the specified quantity of chemical is used for the required area during the operation. On large projects, a power sprayer may be used to save time and labour.

4.4.2 TIME OF APPLICATION

Soil treatment shall start when the foundation trenches and pits are ready to receive mass concrete in foundations. Laying of mass concrete shall start when the chemical emulsion has been absorbed by the soil and the surface is quite dry. Treatment shall not be carried out when it is raining, or soil is wet with rain or sub-soil water. The foregoing also applies in the case of treatment to the filled earth surface within the plinth before laying the subgrade for the floor.

4.4.3 DISTURBANCE

The treated soil barriers shall not be disturbed after they are formed. If by chance, treated soil barriers are disturbed, immediate steps shall be taken to restore the continuity and completeness of the barrier system.

4.4.4 SOIL TREATMENT

Any chemicals conforming to Indian Standards, in water emulsion shall be applied uniformly over the area to be treated. The treated area shall be immediately covered by polythene sheet. It can be uncovered 2 hours before concrete casting.

4.4.5 TREATMENT OF COLUMN-PITS, WALL-TRENCHES AND BASEMENT EXCAVATIONS

The bottom surface and the sides (up to a height of about 300 mm) of the excavations made for column pits, wall trenches and basements shall be treated with the chemical at the rate of 5 litres per sqm of the surface area.

After the column foundations and the retaining walls of the basement come up, the backfill in immediate contact with the foundation structure shall be treated at the rate of 7.5 litres per sqm of the vertical surface of the sub-structure for each side. If water is used for ramming the earth- fill, the chemical treatment shall be carried out after the ramming operation is done by rodding the earth at 150 mm centres close to the wall surface and spraying the chemical with the above dose. The earth shall be returned in layers and the treatment shall be carried out in similar stages. The chemical emulsion shall be directed towards the concrete or masonry surfaces of the columns and walls so that the earth in contact with these surfaces is well treated with the chemical.

In the case of R.C.C. framed structures with columns and plinth beams and R.C.C. basements, with concrete mix 1:2:4 or richer, the treatment shall start at the depth of 500 mm below ground level for

columns and plinth beams. From this depth the back-fill around the columns, beams and R.C.C basement walls shall be treated at the rate of 7.5 litres/sq.m of vertical surface.

4.4.6 TREATMENT OF TOP SURFACE OF PLINTH FILLING

The top surface of the filled earth within plinth beams/walls shall be treated with chemical emulsion at the rate of 5 litres per sq.m of the surface before the sand bed/subgrade is laid. Holes up to 50 to 70 mm deep at 150 mm centres both ways shall be made with 12 mm dia. crow-bar on the surface to facilitate saturation of the soil with chemical emulsion.

4.4.7 TREATMENT OF JUNCTION OF WALL AND FLOOR

To achieve continuity of vertical chemical barrier to inner wall surfaces from the ground level, small channel 30 x 30 mm shall be made at all the junctions of wall and columns with the floor (before laying the subgrade) and rod holes made in the channel up to ground level 150 mm apart and the chemical emulsion poured along the channel at the rate of 7.5 litres/ sqm of the vertical wall or column surface so as to soak the soil right to the bottom. The soil shall be tamped back into place after this operation.

4.4.8 TREATMENT OF SOIL UNDER APRON ALONG EXTERNAL PERIMETER OF BUILDING

The top surface of the consolidated earth over which the apron is to be laid shall be treated with chemical emulsion at the rate of 5 litres/ sqm of the surface before the apron is laid. If consolidated earth does not allow emulsion to seep through, holes up to 50 to 75mm deep at 150 mm centres both ways may be made with 12 mm diameter mild steel rod on the surface to facilitate saturation of the soil with the chemical emulsion.

4.4.9 TREATMENT OF SOIL ALONG EXTERNAL PERIMETER OF BUILDING

After the building is complete, holes shall be made in the soil with iron rods along the external perimeter of the building at interval of about 150 mm and depth 300 mm and these holes filled with chemical emulsion at the rate of 7.5 litres/metre of perimeter of the external wall. If the earth outside the building is graded on completion of building, this treatment shall be carried out on completion of such grading. If the filling is more than 300 mm the external perimeter treatment shall extend to the full depth of filling up to the original ground level so as to ensure continuity of chemical barrier.

4.4.10 TREATMENT FOR EXPANSION JOINTS

Anti-termite treatment shall be supplemented by treating through the expansion joint after the sub-grade has been laid at the rate of 2 litres per linear meter of expansion joint.

4.4.11 TREATMENT OF SOIL SURROUNDING PIPES AND CONDUITS

When pipes and conduits enter the soil inside the area of the foundations, the soil surrounding the points of entry shall be loosened around each such pipe or conduit for a distance of 150 mm and to a depth of 75 mm before treatment is commenced. When they enter the soil external to the foundations, they shall be similarly treated for a distance of over 300 mm unless they stand clear of the walls of the building by about 75 mm.

4.5 SAFETY PRECAUTIONS

All chemicals used for anti-termite treatment are poisonous and hazardous to health. These chemicals can have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mists or swallowed. Person using or handling these chemicals should be warned of these dangers and advised that absorption through the skin is most likely source of accident poisoning. They should be cautioned to observe carefully the safety precautions given below.

These chemicals are usually brought to site in the form of emulsifiable concentrates. The containers should be clearly labelled and should be stored carefully so that children and pet cannot get at them. They shall be kept securely closed.

Particular care shall be taken to prevent skin contact with concentrates. Prolonged exposure to dilute emulsions shall also be avoided. Workers shall wear clean clothing and wash thoroughly with soap and water, especially before eating and smoking. In the event of severe contamination, clothing shall be removed at once and the skin washed with soap and water. If chemicals splash into eyes they shall be flushed with plenty of soap and water and immediate medical attention shall be sought.

The concentrates are oil solutions and present a fire hazard owing to the use of petroleum solvents. Flames shall not be allowed during mixing.

Care shall be taken in the application of chemicals to see that they are not allowed to contaminate wells or springs which serve as source of drinking water.

In case of poisoning suitable measure shall be taken for protection in accordance with IS 4015.

4.6 MEASUREMENTS

The measurements shall be made in sq.m on the basis of plinth area of the building at ground floor only for all operations described above. Nothing extra shall be measured.

4.7 RATE

The rate shall include the cost of all materials and labour involved in all the operations described above including making holes and refilling and making good the same.

5 STRUCTURAL STEEL WORKS**5.1 SCOPE**

This specification covers the general requirements for supply of all steel items where specified, fabrication, inspection, testing and delivery at site of all fabricated structural steel items. This specification also covers design of all connections and substituted members, preparation of all shop fabrication drawings, inspection of fabricated items. The scope of work also includes but is not limited to proper stacking and storage of fabricated materials, transport from place of storage to place of erection, wherever required. All the works shall be carried as per approved QA procedures.

5.2 APPLICABLE CODES STANDARDS AND SPECIFICATIONS

The pertinent clauses of the following Indian Codes, Standards and Specification (latest editions including all applicable official amendments, reaffirmations and revisions) shall apply to the material and workmanship covered by this specification. In the event of the conflict of certain requirements between this specification and the codes referred herein, this specification shall govern.

It is not the intent to specify herein all the codes and standards required for the satisfactory completion of work. The list of codes and standards indicates certain primary codes and standards and not all the codes required for the work under the contract. It is understood that all the pertinent codes and standards shall form the part of this specification whether explicitly indicated or not.

IS 800	General Construction in Steel –Code of Practice
IS 803	Code Of Practice For Design, Fabrication And Erection Of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks.
IS 806	Code Of Practice For Use Of Steel Tubes In General Building Construction
IS 808	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections
IS 813	Scheme of symbols for welding
IS 814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel-Specification
IS 816	Code of Practice for use of Metal Arc Welding for General construction in Mild Steel
IS 822	Code of Procedure for Inspection of Welds
IS 1024	Code of practice for use of welding in bridges and structures subjected to dynamic loading
IS 1161	Steel Tubes for structural purposes-Specification
IS 1182	Recommended Practice for Radiographic examination of Fusion Welded Butt Joints in Steel Plates.
IS 1239	Steel Tubes, Tubular and Other Wrought Steel Fittings-Specification-Part 1: Steel Tubes
IS 1239	Mild steel tubes, tubular and other wrought steel fittings-Part 2:Mild steel tubular and other wrought steel pipe fittings

IS 1363	Hexagon Head Bolts, Screws and Nuts of Product Grade 'C' Part 1: Hexagon Head Bolts (Size range M5 to M64) Part 2: Hexagon Head Screws (Size range M5 to M64) Part 3: Hexagon Nuts (Size range M5 to M64)
IS 1367	Technical Supply Conditions for Threaded Fasteners (All Parts)
IS 1395	Low and medium alloy steel covered electrodes for manual metal arc welding
IS1852	Rolling and Cutting Tolerances for Hot Rolled Steel Products (4 th Rev)
IS 2062	Hot Rolled low, medium and High tensile structural steel
IS 2595	Code of Practice for Radiographic Testing
IS 3502	Steel Chequered Plates-Specification.
IS 3600:	Method of testing fusion welded joints and weld metal in steel (All parts)
IS 3658	Code of Practice for Liquid Penetrate Flaw Detection
IS 3757	Specification for High Strength Structural Bolts
IS 4000	Code of Practice High strength bolts in Steel Structures
IS 4260	Recommended practice for ultrasonic testing of butt welds in ferritic steel.
IS 4353	Submerged arc welding of mild steel and low alloy steels –Recommendations
IS 5334	Magnetic Particle Flaw Detection of Welds-Code of Practice
IS 6639	Specification for Hexagon Bolts for Steel structures
IS 7215	Tolerances for Fabrication of Steel Structures.
IS 9595	Metal Arc Welding of Carbon and Carbon Manganese Steels-Recommendations
IS 12778	Hot rolled parallel flanged section for beams, columns
SP:6(1)	Structural Steel Sections.
AWS D1.1	Structural Welding Code: Steel

5.3 STEEL SUPPLY

All steel and other material shall be procured and supplied by the CONTRACTOR, from the reputed manufacturers as mentioned in tender document. Steel proposed to be procured from other manufacturers shall have prior approval from the OWNER before placement of procurement order. However, OWNER reserves the right to accept or reject material from other manufacturers. Materials from re-rollers will not be accepted. Steel procured shall conform to the applicable codes & standards mentioned in clause 2.0.

CONTRACTOR shall use materials for fabrication as specified in the approved drawings. All materials supplied by the CONTRACTOR shall be in sound condition, of recent manufacture, free from defects such as mill scales, slag intrusions, laminations, pitting, flaky, rust etc. and be of full weight and thickness as specified.

CONTRACTOR shall furnish the mill / manufacturer's test reports, along with the materials and satisfactorily demonstrates the specific grade and quality. Material test certificate shall be original.

All materials required for the work shall be correlated with manufactures test certificates. In the absence of test certificates, CONTRACTOR shall test materials through reputed laboratory approved by PMC/EMPLOYER for establishing quality, at CONTRACTOR's cost and as directed by the PMC/EMPLOYER.

Material supplied against this Test Certificates (TC) should have identification stamped or stencilled on them. All such identification markings shall be authenticated by the inspection agency, which has inspected and approved the material.

The CONTRACTOR shall furnish to the PMC/EMPLOYER duplicate copies of all purchase order copies covering the material ordered by him for the project under reference and test reports.

The PMC/EMPLOYER shall have the right to test random samples to prove authenticity of the test certificates produced by the CONTRACTOR at the CONTRACTOR's cost. Any material found not meeting the required specification would be rejected.

Whenever the CONTRACTOR desires to substitute structural members / shapes, plates for the sizes shown on the drawings, for want of availability of requisite materials, such substitutions shall be made only after authorization in writing by the PMC/EMPLOYER. PMC/EMPLOYER may also direct that substitution be made, when he considers such substitution to be necessary.

5.4 CONTRACTOR'S DRAWINGS (FABRICATION DRAWINGS)

Fabrication drawings shall be prepared by the CONTRACTOR or through an agency approved by PMC/EMPLOYER at his own cost based on the PMC/EMPLOYER's Design drawing "Released for Construction" and their subsequent revisions. All the drawings for the entire work shall be prepared in metric units. The drawings shall preferably be of one standard size and the details shown there in shall be clear and legible. Drawings shall be prepared in computer tools and the details shall be drawn to the minimum scale as specified under.

- a) Marking Plan : 1:75
- b) Joint Details : 1:5; 1:10; 1:1
- c) Elevations: : 1:20

CONTRACTOR shall not commence detailing unless PMC/EMPLOYER's design drawings are officially released for preparation of shop drawings. The CONTRACTOR shall be responsible for the correctness of all fabrication drawings. Fabrication drawings shall be revised by the CONTRACTOR to reflect all revisions in design drawings as and when such revisions are made by the PMC/EMPLOYER.

Key plan prepared by the CONTRACTOR shall indicate the fabrication / erection marking of each member and a table showing the corresponding fabrication drawing number where these members are detailed. Also, each drawing prepared by CONTRACTOR shall indicate corresponding PMC/EMPLOYER's design drawing number with revisions.

Each member shall be detailed separately unless members are identical in all respects with no deviation whatsoever. Shop detail drawings shall show all shearing, punching, drilling, bevel cutting, bending, and all welding in complete detail. All connections and splices shall be designed and detailed by the CONTRACTOR and clearly shown on the drawings. Bill of material shall show number, size, length, weight and assembly work of each erection piece. Bill of material for each drawing shall include fasteners/bolts, nuts, washers and other accessories complete with specification, size, length, numbers, etc for each erection mark and proper identification for each joint. Bill of material shall be prepared

erection mark wise, showing weight of each component part and total weight of each erection mark. All revisions after initial issue of a drawing shall be clearly indicated with issue number and date of revision.

Each drawing prepared by the CONTRACTOR shall clearly indicate Names of OWNER, PMC/EMPLOYER, CONTRACTOR, Project Title, Title of drawing, Scale, Notes, Details of revisions carried out etc; All titles, noting, markings and writings on the drawing shall be in English and all dimensions shall be in metric units. Before the commencement of preparation of fabrication drawings, CONTRACTOR shall discuss with the PMC/EMPLOYER any specific requirement to be followed for fabrication drawing preparation.

No detailed shop drawings will be accepted by the PMC/EMPLOYER unless they are complete and checked and approved by CONTRACTOR's qualified Structural PMC/EMPLOYER and accompanied by an erection plan showing the location of all pieces detailed.

CONTRACTOR should check for erection clearance and ensure that detailing of connections is carefully planned to obtain ease in erection of structures including field-welded connection and bolting. Field connections/splices may be welded, or bolted type as specified in design drawings.

CONTRACTOR shall submit design calculations for each connection detail proposed by him and for any substitution for members, desired by him and approved by the PMC/EMPLOYER. Fabrication drawings not accompanied by calculation for connection details are liable for rejection.

Each lot of drawings sent by CONTRACTOR for approval shall contain a limited number of drawings and shall be in an order and manner which follows erection sequence or as required by PMC/EMPLOYER based on priorities allocated. PMC/EMPLOYER will return one copy of CONTRACTOR's drawing marked with PMC/EMPLOYER's approval/comments. CONTRACTOR shall furnish the PMC/EMPLOYER the required number of prints of all approved drawings for field use and record purpose.

Site splicing may be by welding or by means of high tensile bolts. In the case of welded connection, efficiency of field butt weld shall be considered as 50% and cover plate shall be designed for 50% of the tensile strength of the plates spliced.

In the case of framing beams, the weld between flange and web shall be calculated based on standard formula considering the shear force as the full shear capacity of the web. Continuous weld shall be provided keeping size of weld uniform for the full length of girder. However, in no case the size of weld shall be less than half the web thickness.

Weld between flanges and web both for column as well as beams, shall be made using automatic welding machines, with proper sequence of welds to avoid warping.

Connection of bracings /tie beams to column shall follow the details given in the design drawings. Where such details are not given, the connection shall be designed for 50% of the tensile strength of the member unless design drawings indicate a higher load in the member. The maximum size of the weld shall be less than or equal to the thickness of the rolled section at the location of connection.

Weld between flanges and web both for column as well as beams, shall be made using automatic welding machines, with proper sequence of welds to avoid warping.

Thickness of gusset plates shall be at least equal to the thickness of member connected and shall have adequate cross section to transfer the force at the point. If the members are connected on either side of gusset, thickness of gusset shall be more than sum of thickness of fillet weld on either side of gusset.

PMC/EMPLOYER may review / approve the fabrication drawing at his option some, all or none of the fabrication drawings. Wherever such review is carried out the same shall be restricted to the following.

Review/ approval of the size of members, dimensions and general arrangement but shall not constitute approval of the connections between members and other details.

Correctness of overall dimensions, centre to centre distance, elevations. Important / typical connection details (adequacy of number of bolts / weld length for few connections only will be checked), working points for bracing members and orientation and sizes / sections of members.

It shall be clearly noted by the CONTRACTOR that even where review is done by the PMC/EMPLOYER, the following shall be the sole responsibility of the CONTRACTOR.

- Provision for erection.
- Marking of members.
- Cutting Lengths of members
- Matching of Joints and holes
- Provision kept in the member for all other interconnected members
- Bill of materials.
- Gusset sizes.
- Connections

Approval by PMC/EMPLOYER of any of the fabrication drawings shall not relieve the CONTRACTOR from the responsibility for correctness of engineering, design of connections, workmanship, and fit of parts, details, material, errors or omissions of all work shown thereon. PMC/EMPLOYER's approval shall not invalidate any claim for damages of any kind for incorrectly detailed / fabricated steel, notwithstanding any approval of such drawings by PMC/EMPLOYER.

On completion of fabrication and erection, the CONTRACTOR shall update his fabrication drawings, incorporating all site changes and substitutions and shall submit two (2) sets of hard copies of such "as built" drawings to PMC/EMPLOYER's for record purpose. The CONTRACTOR shall also furnish two sets of soft copies of all final approved Contractors' drawings in the form of CDs.

Time consumed by the CONTRACTOR in securing approval of drawings should not be added to the time allowed for completion of contract. A period of two (2) weeks from the dates of receipt of drawings by the PMC/EMPLOYER should be anticipated for this item of procedure in the schedule.

5.5 FABRICATION

5.5.1 GENERAL

Fabrication shall not be started until CONTRACTOR has received copies of such drawings upon which PMC/EMPLOYER has endorsed his approval. Any work done prior to approval of CONTRACTOR's fabrication drawings will be at the CONTRACTOR's risk. The CONTRACTOR shall make such changes in the design when so directed, which are considered necessary to make the structures conform to the provisions and intent of the specifications, without any additional cost to the OWNER.

All workmanship and finish shall be of the best quality and shall conform to good engineering practice and the best-approved method of fabrication. All materials shall be finished straight and shall be machined / ground smooth, true and square where so specified.

Materials at the shop shall be kept clean and protected from weather. Cutting, punching, drilling, welding and fabrication tolerances shall be generally as per relevant Codes and Standards. In addition, the CONTRACTOR shall strictly adhere to the following.

- All care should be taken to avoid undue welding distortions.
- Complete layout shall be prepared and got approved by the PMC/EMPLOYER before actual fabrications are started. If needed mock-ups may also be prepared.

All fit ups shall be got approved from the PMC/EMPLOYER.

5.6 CONNECTIONS

All shop connections shall be welded unless otherwise specified in PMC/EMPLOYER's design drawing. Field connections can be either welded or bolted and as shown in design drawings. Bolts used for erection shall conform to IS-6639 and as specified in the design drawings. Bolts used for permanent connections shall be high strength tensile bolts and shall conform to grade 'C' as per IS:1363 and property class 8.8 (minimum) as per IS:1367 or as indicated in design drawings.

All connections shall be designed for forces indicated on the design drawings or as specified elsewhere in the specification/standard drawing if not given in the design drawings. The CONTRACTOR shall be responsible for selection of standard connections from AISC Manual of Steel Construction or any other standards approved by PMC/EMPLOYER.

All connections shall be designed and detailed as per guidelines given in IS800 code.

In case of bolted connections, taper washers or flat washers or spring washers shall be used with bolts as necessary. In case of high strength friction grip bolts, hardened washers are used under the nuts or the bolt heads whichever are turned to tighten the bolts. The length of the bolt shall be such that at least one thread of the bolt projects beyond the nut, except in case of high strength friction grip bolts where this projection shall be at least three times the pitch of the thread.

In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, if a longer grip bolt must be used for this purpose.

Not more than one shop splice shall be provided to make up the full length of a member. Shop splices to make the full member lengths shall be of full penetration butt welded type and radiographically tested.

Transportation or the CONTRACTOR's erection methods may require additional splices not shown on the drawings. The CONTRACTOR shall be responsible for the design and detailing of such splices or joints and shall submit these for the PMC/EMPLOYER's approval.

All bolts, nuts, screws, washers, electrodes, etc. shall be supplied / brought to site 10% more than the requirement in each category and size. Rates shall cover the cost of this extra quantity and no additional payment will be made for this extra quantity supplied.

All members likely to collect rain water shall have drain holes provided.

5.7 STRAIGHTENING

Rolled material, before being worked, shall be straightened, unless otherwise specified. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Long plates shall be straightened by passing through a mandrel or levelling rolls and structural shapes by the use of mechanical or hydraulic bar/section straightening machines. Heating or forging shall not be resorted to

without the prior approval of the PMC/EMPLOYER in writing. In case of site fabrication, CONTRACTOR shall obtain PMC/EMPLOYER's approval in writing on the straightening method proposed to be adopted before commencing the work.

Checking of the straightness of the structural members like angles, channels, beams etc. shall be done by using the thread. For checking of the straightness of the column sections piano wire shall be used. The sections, which are twisted beyond repairs, shall not be used for fabrication. Heating or hammering shall not be permitted. After removal of bends structural members shall be submitted for inspection and approval of PMC/EMPLOYER.

5.8 CUTTING

Cutting may be done by shearing, cropping, sawing or machine flame cutting. All re-entrant corners shall be shaped notch free to a radius of at least 12-mm. Sheared or cropped edges shall be dressed to a neat workmanlike finish and shall be free from distortion and burrs.

Hand flame cutting shall be undertaken, only if so permitted by the PMC/EMPLOYER and shall only be carried out by an expert in such work. Hand flame cut edges shall be ground smooth and straight.

Edges of flange cover plates and plates used to form any sections shall be ground smooth.

5.9 PUNCHING AND DRILLING

Holes in secondary members such as Purlins, grits, lacing bars etc. may be punched full size through material not over 12 mm thick. Holes should be clean cut, without burr or ragged edges. Holes for all other connections shall be drilled accurately and the burrs removed effectively. Where several parts are to be connected to very close tolerances such parts shall be first assembled, tightly clamped together and drilled through.

Sub-punching may be permitted before assembly, provided the holes are punched 3 mm smaller in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall not in such cases exceed 16 mm.

When match drilling is carried out in one operation through two or more separate parts, these parts shall be separated after drilling and the burrs removed.

Holes for turned and fitted bolts shall be drilled to a slightly smaller diameter and reamed to a diameter equal to the nominal diameter of the shank or barrel subject to tolerance specified in IS: 919.

Where reamed members are taken apart for transporting or handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted. Poor matching, over drilling and ovality in holes shall be a cause for rejection. Burning holes with gas is strictly prohibited.

Holes may be required to be drilled by the CONTRACTOR at no extra cost at site for installing equipment or steel furnished by other agencies. The information for this will be supplied to the CONTRACTOR by the PMC/EMPLOYER before or after erection of the steel. Holes should be by drilling or other machining process and not by gas cutting sets.

5.10 ROLLING AND FORMING

Plates, Channels, Rolled Steel joists etc., for circular bins, bunkers, hoppers, gantry girders, etc., shall be accurately laid off and rolled or formed to required profile/ shape as called for on the drawings. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection in the field.

5.11 GRINDING

Column ends bearing on each other, resting on base plates, compression joints designed for bearing, base plates coming in contact with column end and cap plate shall be ground smooth to ensure 90% contact with local gap not exceeding 0.10 mm (filler gauge shall be used to check this gap). Bottom edge of knife edge support (bearing stiffener) for crane girder and top of cap plates where the knife edge supports rest shall also be accurately ground as above. All ground surfaces shall be protected from dirt and mechanical damages till the assembly is completed. However, the underside of base plate bearing on grout need not be machined.

5.12 WELDING

Before the start of the work, welding procedure shall be submitted to PMC/EMPLOYER for approval. Welding shall be entrusted to only qualified and experienced welders who shall be periodically tested and graded as per relevant standards.

Welding procedure specification (WPS) shall be established and Qualification of weld procedure (QWP) shall be done as per approved standards. Welders employed shall also be qualified as per above standards prior to taking up fabrication. CONTRACTOR shall obtain approval from PMC/EMPLOYER before the start of the work.

Following pre-qualified welding process shall be employed for fabrication, erection and repair and the same shall have the approval of PMC/EMPLOYER before adopting the welding process on the job.

- Submerged Arc Welding (SAW).
- Shield Metal Arc Welding (SMAW).
- Gas Metal Arc Welding (GMAW).
- Gas Tungsten Arc Welding (GTAW)

All welds shall be free from defects like blowholes, lack of penetration, undercutting, cracks etc. All welds shall be cleaned of slag or flux and show sections, smoothness of weld metal, feathered edges without overlap and freedom from porosity.

50mm on either side of the surfaces on which weld metal is to be deposited shall be smooth, uniform, free from fins, tears, burrs, cracks and absolutely free from grease, paint, loose scale, moisture or any other substance which would adversely affect quality and strength of weld.

Machining, thermal cutting or grinding may be employed for joint preparation or removal of unacceptable work or metal. The weld edges shall be smooth & regular surface, free from cracks & notches. Flame cut material above 50mm thick shall be pre-heated as per relevant standards prior to flame cutting and shall be subjected to PMC/EMPLOYER's approval.

All weld fit-up shall comply with tolerances specified in the relevant standards. The parts to be joined by fillet welds shall be brought into close contact as practicable and within the tolerable limits as per relevant codes & standards.

All tack welds shall be made using qualified procedure and qualified welders. Any preheat requirement specified in the welding procedure shall also apply to tack welds. All tack welds shall be examined visually for defects and if found defective, shall be removed and re-welded. Throat thickness, leg length and length of tack weld shall be as per IS:9595.

Welding of temporary attachment/fixtures to retain fit up is permitted in case the parts have a nominal thickness of at least 10 mm. Temporary attachments are welded at the minimum distance of at least 50 mm from the weld seam. Welding of temporary attachments/fixtures into the joint slot is not allowed. All temporary fixtures shall be removed after welding, by grinding them to weaken the welded portion and hammering thereafter followed by grinding the portion of any weld remaining on the base metal. A dye check at the discretion of the quality surveyor shall be done to detect any crack/defect at the point of fixture temporary weld.

It is not allowed to turn over and carry over heavy assemblies in tacking condition to control the geometric dimensions to the requirements of the drawings. The work shall be positioned for flat welding wherever practicable and overhead weld shall be avoided as far as possible.

In the joints of the parts with dissimilar thickness smooth transition of one part to the other must be provided by way of the gradual decreasing of the thickness of the thicker part with the slope of the surface not exceeding 15 degree.

Welding shall not be done when the surface of the members are wet or exposed to rain or high wind velocities unless the welding operator and the work are properly protected.

In joints connected only by fillet welds, the minimum size of fillet weld to be used shall be as per IS 9595-1996.

Welds shall be defect free and surfaces shall be thoroughly cleaned to remove all visible weld defects and extra material.

For all built up sections such as Columns, Crane Girders etc welding between web and flange plates shall be carried out by SAW process. Especially for butt welds of Crane girders full penetration of weld between top of web plate and top flange shall be ensured. Welding shall be continuous and shall be on both sides of the connecting member. One side fillet weld is not acceptable.

5.13 **WELDING CONSUMABLES**

Electrodes, filler wires and flux used for welding shall be from approved manufacturers/Suppliers. CONTRACTOR shall submit the list of Electrode manufacturers proposed to be procured to the PMC/EMPLOYER for approval. The CONTRACTOR shall furnish certification that electrode or electrode flux combination will meet the requirements of classification. The classification and size of electrode, arc length, voltage & amperage shall be suited to type and thickness of material, type of groove, welding positions and other circumstances attending work.

Only low hydrogen electrodes shall be used for welding. All electrodes having low hydrogen covering shall conform to relevant acceptable standards. These electrodes shall be purchased in hermetically sealed containers or baked by the user as recommended by electrode manufacturer. Electrode flux coating shall be sound and unbroken. Broken or damaged coating shall cause the electrodes to be discarded. Before welding, the electrodes shall be dried in a holding oven at 120°C at least for one (1) hour or as per manufacturer's recommendations. Only limited quantity shall be issued to the welders. The electrodes shall be kept in "carry ovens" and shall not be exposed to the atmosphere.

Welding plants and accessories shall have capacity adequate for welding procedure laid down and shall satisfy appropriate standards and be of approved make and quality. CONTRACTOR shall furnish and obtain approval from PMC/EMPLOYER the details of equipment he proposes to deploy for the works. All the electrical plant in connection with the welding operation shall be properly and adequately earthed and adequate means of measuring the current shall be provided. Proper safety rules shall be strictly followed.

5.14 TESTING, INSPECTION AND REPORTS**5.14.1 GENERAL**

On award of work, the CONTRACTOR shall submit to PMC/EMPLOYER, his Field Quality Plan (FQP), outlining the types, details and extent of inspection he proposes to execute, covered in the rates quoted for various items of work.

CONTRACTOR shall give due notice to PMC/EMPLOYER in advance of the materials or workmanship getting ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for PMC/EMPLOYER's approval / inspection. The fact that certain material has been accepted at CONTRACTOR's shop shall not invalidate final rejection at site by PMC/EMPLOYER if it fails to conform to the requirements of these specifications, be in proper condition or has fabrication inaccuracies which prevent proper assembly.

No material shall be painted or dispatched to site without the inspection and approval by PMC/EMPLOYER unless such inspection is waived in writing by the PMC/EMPLOYER.

Shop inspection by PMC/EMPLOYER or submission of test certificates and acceptance thereof by PMC/EMPLOYER shall not relieve CONTRACTOR from the responsibility of furnishing material conforming to the requirements of these specifications, nor shall it invalidate any claim which the PMC/EMPLOYER may make because of defective or unsatisfactory material or workmanship

CONTRACTOR shall provide all the testing and inspection services and facilities for shop work except where otherwise specified. CONTRACTOR's inspection work shall be under the control of competent Chief Inspector whose primary responsibility is inspection (reporting to Management) and not to production department.

For fabrication work carried out in the field, the same standard of supervision and quality control shall be maintained as in shop fabricated work. The inspection and testing shall be conducted in a manner satisfactory to PMC/EMPLOYER. The inspection and testing on structural steel members shall be as set forth below:

5.14.2 MATERIAL TESTING

All materials conforming to a particular Indian or any other standard as called for shall be tested as required by such standard. Proof in the form of certified test reports or mill certificates indicating that the required tests have been carried out as per specification at the source is acceptable.

If mill test reports are not available for any steel materials, the same shall be got tested by CONTRACTOR to PMC/EMPLOYER's satisfaction to demonstrate conformity with the relevant specification at his own cost.

Raw material with cracks, seams, laps, lamination and heavy pitting are not acceptable. Ultrasonic testing of plates above 50 mm thick shall be carried out for the soundness of material.

PMC/EMPLOYER has option to specify additional inspection or testing as he deems necessary and the additional cost of such testing shall be borne by the CONTRACTOR.

The CONTRACTOR shall maintain records of all inspection and tests, which shall be made freely available to the PMC/EMPLOYER and shall be submitted to the PMC/EMPLOYER on completion of each stage of work.

5.14.3 TESTS ON WELDS

All welds shall be tested for flaws by any of the methods described under. The choice of the method adopted shall be determined by the PMC/EMPLOYER. Following methods are generally recommended for the quality control of welded joints:

5.14.3.1 Magnetic Particle Test (MPT)

All fillet welds in general structural steel work shall have their final passes fully tested by MPT. However, for fillet welds of size 10mm and above and /or critical areas, the root and final passes shall be tested using MPT. The PMC/EMPLOYER shall however decide the requirements of this additional testing. For Complete penetration butt welds, the root and final passes shall be tested using MPT. All MPT shall be as per relevant acceptable standards. Defects if found, shall be repaired and retested. MPT shall be carried out using alternating current only. Direct current may be used with the permission of the PMC/EMPLOYER. The cost of demagnetizing after testing is deemed to be included in the quoted rates of the CONTRACTOR.

5.14.3.2 Dye Penetrant Test (DPT):

MPT may be substituted by Dye Penetrant Inspection where the former is not feasible due to configuration. The testing should be in accordance with relevant acceptable standards.

5.14.3.3 Radio-graphic Inspection (RT):

All completed full penetration butt welds to a length of about 10% shall be radio-graphed as per PMC/EMPLOYER's directive in accordance with the relevant acceptable standards. In case of crane girders 100 percent of the splicing shall be inspected by RT. In the case of hoppers of coal bunkers at least 10% of the circumferential as well as seam welds shall be inspected by RT.

5.14.3.4 Ultrasonic Testing (UT):

Wherever built up sections for crane runway girders are fabricated, the T-joints of the sections shall be subjected to ultrasonic testing. 100 percent length of the seam as well as circumferential welds of hoppers of coal bunkers shall be inspected by UT.

5.14.3.5 Acceptance Standard

The acceptable standards for various weld tests shall be as per ASME Sec VIII- Div I or relevant acceptable standards.

5.14.4 INSPECTION OF WELDS

Welding shall be carried out as per approved WPS and QWS by qualified welders.

All welds shall be inspected for flaws by any of the standard methods described under the choice of the method adopted shall be determined by the PMC/EMPLOYER.

The correction of defective welds shall be carried out as directed by the PMC/EMPLOYER without damaging the parent metal. When a crack in the weld is removed, magnetic particle inspection or any other equally positive means as prescribed by the PMC/EMPLOYER shall be used to ensure that the whole of the crack and material up to 25 mm beyond each end of the crack has been removed. Cost of all such tests and operations incidental to correction shall be to the CONTRACTOR's account.

CONTRACTOR shall perform the following minimum tests on welds with no cost implication to the PMC/EMPLOYER. CONTRACTOR's quoted rate is deemed to have included the cost of such tests.

SI No	Location & Type of weld	Type of Test	Extent of test	Remarks
1.	All fillet welds in general other than those covered under the SI no 2 ,3,5,7 & 8	DPT	1% of fillet weld with minimum of one test on each member / joint	
2.	Fillet welds for plate thickness greater than 25 mm and fillet size more than 10 mm	MPT/ DPT	10%	
3.	Flame cut edges of plates more than 38 mm for fillet weld	MPT / DPT	100%	
4.	Flame cut edges of plates greater than 25 mm for butt welds,	MPT / DPT	100%	
5.	Fillet welds between tension flanges and webs	MPT / DPT	100%	
6.	Full penetration butt welds	DPT	100 %	DPT shall be carried out after back gouging before second side welding
7.	Fillet Weld greater than 12 mm on flame cut edges of low alloy steel	MPT	100%	
8.	Fillet Welds for built up girders, columns and other heavy structures for penetration.	Macro etch test	One (1) test per structure for penetration	
9.	Butt welds of thickness greater than 25 mm and less than 32 mm	MPT / DPT	100 %	
10.	Butt welds of thickness greater than 32 mm	RT	100%	

11.	Butt welds of rolled sections having depth greater than 600 mm	RT	100%	

In addition to the minimum tests to be conducted by the CONTRACTOR, PMC/EMPLOYER reserves his right to direct the CONTRACTOR to conduct additional tests. The extent, type and location of test shall be decided by the PMC/EMPLOYER. These additional tests shall be conducted by the CONTRACTOR or through an approved agency in presence of the PMC/EMPLOYER. If the test fails, the cost of that test shall not be payable to the CONTRACTOR. The tests which when successful will be paid for at the rates specified in the schedule.

5.14.5 WELD DEFECTS AND ACCEPTABLE CRITERIA

Type of defect	Acceptance criteria	Remarks
Cracks	Not acceptable	
Incomplete or lack of Fusion	Not acceptable	
Mis-alignment of butt welds	0.25 x T (maximum of 3 mm)	T: Thickness of thinner plate
Reinforcement	Max reinforcement of 2 mm for t < 10 mm 3 mm for t > 10mm < 15 mm. 4 mm for 15 mm and greater	
Undercut	0.25 mm deep max	
Sharp edges	Min radius of 2 mm	

5.14.6 WELD REPAIRS

Whenever weld repair is required, CONTRACTOR shall give prior intimation to the PMC/EMPLOYER and obtain permission before the repair is taken up. When a defect is detected in a weld, it shall be removed by cutting / grinding and smooth blending of the area with parent metal without sharp edges, corners. If welding is required, the same shall be done using the qualified procedure / welder and stage inspection as per the original weld. Correction of defect in the same portion of the weld shall not be allowed more than two (2) times. Portion of the welding seams, which have been subjected to repair, must be indicated in the weld inspection reports.

5.14.7 INSPECTION AND TESTS ON STRUCTURAL STEEL FABRICATED MEMBERS

Inspection and tests on Structural Steel Fabricated Members shall be as set forth below:

- All the fabricated parts of Structural Steel members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment and surface finish are in accordance with the requirements shown on the approved CONTRACTOR's shop drawings and/or PMC/EMPLOYER's drawings.
- Fit ups shall be examined by the quality surveyor as per the approved QA plan prior to welding the joint. All welds shall be inspected for flaws by the method described under the Clause 7.4 (Inspection Of welds).
- The dimensions of the fit ups shall be maintained as specified in the fabrication drawings.
- Dimensions of all the assemblies and sub-assemblies shall be as per fabrication drawings within the tolerances specified in IS 7215.

5.14.8 TOLERANCES

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS:1852 for indigenous steel and equivalent applicable codes for imported steel. The tolerances for fabrication of structural steel shall be as per IS:7215.

5.14.9 TEST FAILURE

In the event of any failure of welding, structural steel members to meet inspection or test requirements, the CONTRACTOR shall notify the PMC/EMPLOYER or his authorised representative. A design concession request must be made and got approved from the PMC/EMPLOYER or his representative before repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by PMC/EMPLOYER.

CONTRACTOR shall maintain records of all inspection and testing which shall be made available to the PMC/EMPLOYER or his authorised representative, for three years from the date of completion of the contract.

The PMC/EMPLOYER has the right to specify additional testing as he deems necessary, and the additional cost of such testing shall be borne by the PMC/EMPLOYER only in case of successful testing.

5.14.10 DRILLING HOLES FOR OTHER WORKS

As a part of this Contract, holes in members required for installing equipment or steel furnished by other manufacturers or other CONTRACTORS shall be drilled by the CONTRACTOR at no extra cost to the PMC/EMPLOYER. The information for such extra holes will be supplied by the PMC/EMPLOYER.

5.14.11 MARKING OF MEMBERS

After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be clearly visible.

All erection marks shall be on the outer surface of all sections and near one end, but clear of bolt holes. The marking shall be so stamped that they are easily discernible when sorting out members. The stamped marking shall be encircled boldly by a distinguishable paint to facilitate easy location.

Erection marks on like pieces shall be in identical locations. Members having lengths of 7.0 m or more shall have the erection mark at both ends.

5.14.12 ERRORS

Any error in shop fabrication which prevents proper assembling and fitting up of parts in the field by moderate use of drift pins or moderate amount of reaming will be classified by the PMC/EMPLOYER as defective workmanship. In case PMC/EMPLOYER rejects such material or defective workmanship, the same shall be replaced by the materials and workmanship conforming to the PMC/EMPLOYER's requirements by CONTRACTOR free of cost at site.

5.15 QUALITY SURVEILLANCE

5.15.1 GENERAL

The PMC/EMPLOYER shall subject all works and materials covered by this specification to Inspection.

The CONTRACTOR shall provide free access in his shop during working hours for the inspection staff, designated by the PMC/EMPLOYER, at all phases of the work and assist them where necessary in conducting the inspection. The CONTRACTOR shall expeditiously furnish all gauges, instruments and other necessary measuring equipment required for inspection of the work in the shop. The shop inspection by the inspector is intended to ensure that the material and workmanship are in accordance with this specification, but it will not relieve the CONTRACTOR of any of his responsibilities for the product. The inspector's inspection will include, but not be limited to, the following:

5.15.2 MATERIAL

The inspector will ascertain that only materials conforming to the requirements of this specification are used.

5.15.3 DIMENSION AND TOLERANCES

The PMC/EMPLOYER will ensure and check that the structural members conform to the dimensions and tolerances as set out on the drawings and as required by the specification.

5.15.4 WELDING PROCEDURE

The PMC/EMPLOYER will witness the welding and testing of any procedure qualification tests that are required by this specification. The PMC/EMPLOYER will also check that welding procedure (including the electrode, flux, current, arc voltage, speed of travel) used are in accordance with the approved welding procedures.

5.15.5 WELDING EQUIPMENT

The PMC/EMPLOYER will check the welding equipment to be used for the work to ensure that it is in such condition as to enable qualified welders to follow the procedures.

5.15.6 WELDER AND WELDING OPERATOR QUALIFICATIONS

The PMC/EMPLOYER will permit welding to be performed only by welders and welding operators who are qualified by tests in accordance with relevant standards

When the quality of a welder or welding operators' work, appears to be below the requirements, the PMC/EMPLOYER may require testing of his qualifications by necessary tests.

5.15.7 WELDS

The PMC/EMPLOYER will ascertain that the sizes, length and the location of all welds conform to the requirements of this specification and the approved fabrication drawings. Temporary welds used for the works shall be removed and ground flush with the original surface.

The PMC/EMPLOYER will identify with a distinguishing mark of all parts of the joints that he has inspected and accepted.

The CONTRACTOR shall comply with all the demands of the PMC/EMPLOYER to correct improper workmanship and to remove and replace, or correct as instructed, all welds found defective or deficient.

In the event of faulty welding or its removal for rewelding results in damage to the base metal in the judgment of the PMC/EMPLOYER, or its retention is not in accordance with the intent of the plans and specification, the CONTRACTOR shall remove and replace the damaged materials at his own cost.

5.16 METHOD OF MEASUREMENT

For the purpose of payment, the weight of the actual completed structures shall be calculated from the approved drawings for different items of work. The CONTRACTOR shall submit to the OWNER relevant material list containing weight of each item.

No allowances will be permitted for bolts, nuts, washers, studs, screws etc, galvanizing, welding or for rolling margins. One tonne for the purpose of payment shall mean ONE METRIC TONNE i.e. 1000 Kg. Permanent bolts, however, will be considered for payment against the relevant item under schedule of items.

The weight of a member made from standard rolled section such as beams, channels, angles, etc. shall be based on the standard IS:808 without deductions for holes, notches, bevel cuts, etc. Where a component consists of a cut rolled sections, the full weight of the rolled section shall be considered only if more than half the depth of the original section is used. Otherwise, only half the section unit weight shall be considered for calculation of the weight of the components. Deductions shall be made in the weight of gussets/plates for cuts and notches of 900 sq. cm. or larger.

For gussets/plates used in trusses, bracings, columns, beams, etc, the area shall be that of the minimum circumscribing rectangle except as stated in 16.3 above.

The weight of any built-up members shall be based on the weight of each component

5.17 PROTECTIVE COATING FOR STRUCTURAL STEEL

5.17.1 SCOPE

This specification covers the general requirement of hot dipped galvanising of steelwork. It covers the supply of all materials, labour, tools, plant, equipment, necessary to galvanise the structures in accordance with specifications.

5.17.2 APPLICABLE CODES AND SPECIFICATIONS

The following Specifications and Codes of Practice are made a part of this specification. All Specifications and Codes of Practice referred to herein shall be the latest editions including all

applicable official amendments and revisions. In case of discrepancy between this specification and those referred to herein, this Specification shall govern.

IS: 1367	Hot-dip Galvanised Coatings on Threaded Fasteners. (Part-13)
IS: 2629	Recommended Practice for Hot-dip Galvanising on Iron and Steel.
IS: 2633	Methods of Testing Uniformity of Coating on Zinc Coated Articles
IS: 4736	Hot-dip Zinc Coatings on Mild Steel Tubes.
IS: 4759	Hot-dip Zinc Coatings on Structural Steel and Other Allied Products.
IS: 5905	Sprayed Aluminium and Zinc Coatings on Iron and Steel.
IS: 6158	Recommended Practice for Safeguarding Against Embrittlement of Hot-dipped Galvanised Iron and Steel Products.
IS: 6159	Recommended Practice for Design and Fabrication of Material Prior to Galvanising.
IS: 6745	Method for Determination of Mass of Zinc Coating on Zinc Coated Iron and Steel Articles.
IS: 13229	Zinc for galvanising

5.17.3 MATERIAL

Zinc used for galvanising shall conform to grade Zn 98.5 as per IS: 13229. Chemical composition of the metal shall be as per Table 1 of the above code with minimum zinc content of 98.5%.

The mass of Zinc coating per square meter of exposed surface shall be as specified in the Schedule of Quantities and Prices.

Surfaces of steel work exposed to rural and non-polluted environment shall normally be protected with a minimum of 610 gms/m² of Zinc for an expected coating life of 10 years.

Surfaces of steel work exposed to industrial and un-polluted marine environments shall normally be protected with a minimum of 910 gms/m² of Zinc, for an expected coating life of 20 years.

5.17.4 GALVANISING PLANT

The CONTRACTOR shall indicate in his bid about the location of galvanising plant where galvanising work will be carried out. Prior approval shall be obtained from PMC/EMPLOYER if galvanising is proposed to be carried out outside Contractor's plant.

5.17.5 SURFACE PREPARATION

If the steel work to be galvanised is contaminated by oil, grease or paint, pre-treatment with special solvents will be necessary for their removal. Generally, a Sodium Hydroxide solution obtained by dissolving 10-15 kg of Sodium Hydroxide in 100 litres of water is used. The temperature of the solution shall be kept at about 85-90°C and immersion time shall vary from 10-20 minutes depending on the degree of contamination. The work shall be so handled in a degreasing bath, as to allow free circulation of the solution over all surfaces of the steel work taking due care to clean all the scum collected. Several proprietary reagents are also available, which, if approved by Owner, may be used for degreasing the works, as per the instructions of the manufacturers.

Immediately after degreasing, the steel work shall be rinsed in hot water having a temperature of about 60 °C, followed by a final rinse in cold running water.

The degreased rinsed steel work will now be subjected to pickling to remove all the scales etc and to expose the base metal surface. Both Hydrochloric Acid and Sulphuric Acid may be used for pickling. Hydrochloric Acid will be used at room temperature whereas, in the case of Sulphuric Acid better results are obtained with acid temperature at 60-80 °C. Pickling shall be carried out as per clauses 4.3.1 to 4.3.5 of IS: 2629. Special care shall be taken to avoid Over Pickling.

After pickling, the steel work shall be rinsed clean in running water.

Flux is a chemical compound which helps maintaining surface of 'works' free from oxides. In the 'wet process' (hot dip galvanising), the flux is spread as a molten blanket over the galvanizing bath. Primary purpose of the flux is to help in keeping the surfaces of both the 'work' and the molten Zinc from oxide at the time of reaction. Fluxing shall be generally carried out as per clause 4.6 of IS: 2629.

5.17.6 WORKMANSHIP

After all shop work is complete, all structural material shall be punched with the erection mark to be hot-dip galvanised. Before galvanising, the steel shall be thoroughly cleaned of any paint, grease, rust, scale, acid or alkali or such other foreign matters as are likely to interfere with the galvanising process or with the quality and durability of the zinc coating as specified in clause 4 of IS : 2629. Pickling followed by Rinsing shall be carefully and properly done as specified in IS: 2629.

The control of bath temperature is essential if the quality of the product is to be consistent and Zinc is to be used economically. 'Works' should be galvanized at the lowest possible temperature, which will allow free drainage of Zinc from the work piece during withdrawal. The bath temperature may vary from 440 °C to 460 °C and a working temperature of 450 °C is normally used.

The galvanised surface shall consist of continuous & uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be reasonably smooth and free from imperfections as flux, ash and bare patches, black spots, pimples, lumpiness, runs, rust stains, bulky white deposits and blisters. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable for rejection. Sampling and nos. of test for coating characteristics shall be as specified in IS: 4759. Mass of zinc coating may be determined in accordance with IS: 6745.

All galvanised members shall be treated with Sodium Dichromate solution or an approved equivalent after galvanising, so as to prevent white storage stains.

Dross shall be allowed to settle at the bottom of the Zinc bath and should not be disturbed unnecessarily during dipping operation. As far as possible the 'work' shall not be sunk to the bottom of the bath during galvanizing.

The 'work' should be immersed as rapidly as possible as the amount of dross increases with the time of contact with the flux blanket in the Wet Process. The speed of immersion also influences the uniformity of coating.

The time of immersion for a 'work' depends on several factors such as its chemistry, size, thickness, etc. In most cases the 'work' shall be left in the bath until it reaches the temperature of the bath which is usually indicated by the stopping of its boiling action. It is then withdrawn without much delay. Galvanising of each member shall be carried out in one complete immersion. Double dipping will not be permitted.

The rate of withdrawal which determines the thickness of the unalloyed zinc layer left on the 'work' varies according to the process being operated, and the shape of the 'work'. Special jigs and carriers may be used for dipping and withdrawing the 'works' in batches. The rate of withdrawal shall be controlled so that Zinc drains freely from the surface. 'Works' are withdrawn through a bath of clear Zinc to avoid contamination by flux. Where the 'works' are withdrawn through a flux blanket, it is recommended to quench the 'works' to remove flux residues.

Small 'works' such as bolts, nuts and washers, handled in baskets should be centrifuged to remove excess zinc immediately while the coating is still in molten condition. The quality of finish depends on the rapidity with which the work is transferred from the galvanizing bath to the centrifuge. After centrifuging, the 'works' should be immediately tipped into water to allow the coating to set and to prevent the works from sticking to each other. Threads on the 'works' which are unsuited for centrifuging shall be cleaned with a rotating wire brush immediately after galvanizing and before the coating sets. It should be confined only to the threaded portion of the 'works'.

The Zinc coating on freshly galvanized surfaces when exposed to humid and poorly ventilated conditions during storage and/or transport react with the moisture, carbon dioxide, oxygen etc. in the atmosphere forming a mixture of salts which are white in colour known as 'white rust' or 'wet storage stain'. To prevent this white colour formation, a post treatment like chromating is recommended. The chromating solution contains one percent sodium dichromate and half percent sulphuric acid and the solution shall be kept to room temperature. The galvanized 'works' are dipped into the chromating solution after galvanizing and water quenching operations.

Galvanized 'works' shall not be stacked immediately after quenching to avoid flaking of coating. The 'works' shall be allowed to dry before any handling operation is taken up.

Regarding working condition and safety measures for the galvanizing shop the provisions stipulated in Appendix –B of IS: 2629 shall be strictly adhered to.

5.17.7 INSPECTION AND TESTING

The Zinc coating shall be adherent, smooth, reasonably bright, continuous and free from imperfections, such as but not limited to flux, ash & dross inclusions, bare & black spots, pimples, lumpiness, rust stains, bulky white deposits and blisters. The presence of any of these defects noticed on visual or microscopic inspection shall render the work liable for rejection. Sampling and numbers of tests for acceptance of coating characteristics shall be as specified in IS: 4759.

Uniformity of thickness of Zinc coating on the works shall be tested in accordance with Preece test described in IS: 2633.

Mass of Zinc coating shall be determined in accordance with IS: 6745.

Adherence of the Zinc coating on fabricated steel Works shall be tested by pivoted hammer test as described in IS: 2629.

Adherence of the Zinc coating on hard ware shall be tested using Knife Test as described in IS: 2629.

Enough care should be exercised while storing, packing and handling of galvanised works. Contractor shall ensure that galvanising is not damaged in transit. While storing and transporting, adequate ventilation should be provided as otherwise 'White rust' or 'Wet storage stain' may result with humidity and atmospheric gases. It is sometimes necessary to store galvanised 'works' with spacers in between. They are also sometimes kept at an inclination to facilitate drainage of water if collected on the 'works'. In areas where there is substantial variation in day and night temperature and hence possibility of condensation the storage area may have to be kept warm by providing heaters. In the event of occurrence of any damage, Contractor shall at its own cost adopt scrapping & re-galvanising the member to satisfy the specific requirements.

5.17.8 METHOD OF MEASUREMENT

Galvanising work shall not be measured separately if galvanising is already included in the scope of item of work of fabrication/erection of steel.

In case the galvanising is to be carried out on already fabricated steel work, a separate rate for galvanising shall be quoted as called for in the Schedule of Quantity. The weight of the actual completed structures including weight of bolts, nuts and washers shall be calculated from the approved drawings for different items of work and NO ALLOWANCE in weight will be made for weight of zinc added due to galvanising.

6 MORTARS**6.1 LIST OF BUREAUS OF INDIAN STANDARD CODES**

S. No.	I.S. No.	Subject
1	IS 269	Specification for 33 grade ordinary Portland cement
2	IS 383	Specification for coarse and fine aggregate from natural source for concrete.
3	IS 455	Specification for Portland slag cement.
4	IS 460 (Part I)	Specification for test sieves: wire cloth test sieves.
5	IS 650	Specification for standard sand for testing of cement
6	IS 1269	Specification for 53 grade ordinary Portland cement
7	IS 1344	Specification for calcined clay Pozzolana.
8	IS 1489	Specification for Portland pozzolana cement
9	IS 1542	Specification for sand for plaster
10	IS 1727	Methods of Test for Pozzolana materials
11	IS 2116	Specification for sand for masonry mortar.
12	IS 2250	Code of practice for preparation and use of masonry Mortar.
13	IS 2386 (Pt-I)	Method of test for aggregate for concrete (Particle size and shape)
14	IS 2386 (Pt-II)	-Do- Estimation of deleterious materials and organic impurities.
15	IS 2386 (Pt-III)	-Do- Specific gravity, density, voids, absorption and bulking.
16	IS 3025	Method of sampling and test for water
17	IS 3406	Specification for masonry cement.
18	IS 3812 (Part I)	Specification for fly ash for use as pozzolana in cement mortar and concrete
19	IS 3812 (Part II)	Specification for fly ash for use as admixture in cement mortar and concrete

20	IS 4031 (Part I) to (Part XIII)	Method of Physical test for hydraulic cement
21	IS 4032	Method of chemical analysis of Hydraulic cement.
22	IS 8041	Rapid hardening Portland cement.
23	IS 8042	Specification for white cement
24	IS 8043	Hydrophobic Portland cement
25	IS 8112	Specification for 43 grade ordinary Portland cement
26	IS 11652	Woven HDPE sacks for packing cement
27	IS 11653	Woven polypropylene sacks for packing cement
28	IS 12174	Jute synthetic union bags for packing cement

6.2 GENERAL

Desirable properties of mortars for use in masonry are:

- a. Workability
- b. Water retentivity
- c. Rate of stiffing
- d. Strength
- e. Resistance to rain penetration
- f. Durability

6.3 MATERIALS

6.3.1 WATER

6.3.1.1 Water used for mixing and curing shall be clean and free from injurious quantities of alkalis, acids, oils, salts, sugar, organic materials, vegetable growth or other substance that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing. The Ph value of water shall be not less than 6. The following concentrations represent the maximum permissible values: (of deleterious materials in water).

- a. Limits of Acidity: To neutralize 100ml sample of water, using phenolphthalein as an indicator, it should not require more than 5ml of 0.02 normal NaOH. The details of test shall be as given in IS 3025 (part 22).
- b. Limits of Alkalinity: To neutralise 100ml sample of water, using mixed indicator, it should not require more than 25ml of 0.02 normal H₂SO₄. The details of tests shall be as given in IS 3025 (part 23).
- c. Percentage of Solids: Maximum permissible limits of solids when tested in accordance with IS 3025 shall be as under:
 - Organic 200mg/ litre
 - Inorganic 3000 mg/ litre
 - Sulphates 400 mg/ litre
 - Chlorides 2000 mg/ litre.-For concrete not containing embedded steel and

500 mg./litre. -For reinforced concrete work.
Suspended matter 2000 mg/ litre

Water found satisfactory for mixing is also suitable for curing. However, water used for curing shall not produce any objectionable stain or unsightly deposit on the surface.

6.3.1.2 Sea water shall not be used for mixing or curing

6.3.1.3 Water from each source shall be tested before the commencement of the work and thereafter once in every three months till the completion of the work. In case of ground water, testing shall also be done for different points of drawdown. Water from each source shall be got tested during the dry season before monsoon and again after monsoon.

6.3.2 CEMENT

Shall be as per 3.4.1

6.3.3 FINE AGGREGATE

6.3.3.1 Aggregate most of which passes through 4.75 mm IS sieve is known as fine aggregate. Fine aggregate shall consist of natural sand, crushed stone sand, crushed gravel sand stone dust or marble dust, fly ash and broken brick (Burnt clay). It shall be hard, durable, chemically inert, clean and free from adherent coatings, organic matter etc. and shall not contain any appreciable amount of clay balls or pellets and harmful impurities e.g. iron pyrites, alkalis, salts, coal, mica, shale or similar laminated materials in such form or in such quantities as to cause corrosion of metal or affect adversely the hardening, the strength, the durability or the appearance of mortar, plaster or concrete. The sum of the percentages of all deleterious material shall not exceed 5%. Fine aggregate must be checked for organic impurities such as decayed vegetation humps, coal dust etc. in accordance with the procedure prescribed in Appendix 'A' as given under.

APPENDIX A DETERMINATION OF PARTICLE SIZE

In order that the sieves shall not be overloaded, care must be taken to ensure that the maximum sieve loads shown in Table are not exceeded at the completion of sieving.

I.S. Sieve Designation	Maximum weight for	
	45 cm dia sieve kg	30 cm dia sieve kg
45 mm	10	4.5
40 mm	8	3.5
31.5 mm or 22.1 mm	6	2.5
20 mm	4	2.0
16 mm or 12.5 mm	3	1.5
10 mm	2	1.0
5.6 mm	1.5	0.75
4.75 mm	1.0	0.50
3.35 mm	-	0.30

The sample weight taken will thus normally require several operations on each sieve. Each sieve should be taken separately over a clean tray or receiver until no more than a trace passes, but in any case for

not less than two minutes. Materials should not be forced through the apertures but hand placing is permitted. A light brush should be used with fine sieves. The cumulative weight passing each sieve should be calculated as percentage of the total sample weight to the nearest whole number.

6.3.3.2 Silt Content : The maximum quantity of silt in sand as determined by the method prescribed shall not exceed 8%. Fine aggregate containing more than allowable percentage of silt shall be washed as many times as directed by PMC/Employer so as to bring the silt content within allowable limits for which nothing extra shall be paid.

6.3.3.3 Grading : On the basis of particle size, fine aggregate is graded in to four zones. The grading when determined shall be within the limits given in Table 3.1 below. Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 micron IS sieve, by a total amount not exceeding 5 per cent, it shall be regarded as falling within that grading zone.

IS Sieve	Percentage passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 microns	15-34	35-59	60-79	80-100
300 microns	5-20	8-30	12-40	15-50
150 microns	0-10	0-10	0-10	0-15

Note 1: For crushed stone sands, the permissible limit on 150 micron sieve is increased to 20 per cent. This does not affect the 5 per cent allowance permitted in 3.1.3.4 (e) (1) applying to other sieves.

Note 2: Allowance of 5% permitted in 3.1.3.4 (e) (1) can be split up, for example it could be 1% on each of three sieves and 2% on another or 4% on one sieve and 1% on another.

Note 3: Fine aggregate conforming to Grading Zone IV shall not be used in reinforced cement concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

Note 4: Sand requiring use for mortar for plaster work shall conform to IS 1542 and for masonry work shall conform to IS 2116.

6.3.3.4 Type and grading of fine aggregate to be used shall be specified. It shall be coarse sand, fine sand, stone dust or marble dust, fly ash and surkhi. Use of sea sand shall not be allowed, unless otherwise specified.

- Coarse and fine sand shall be river sand. Its grading shall fall within the limits of grading
- Zone I, II, III, IV of Table. Grading of sand shall conform to IS 2116 for use in Masonry work.
- Stone dust shall be obtained by crushing hard stones or gravel. Its grading shall fall within the limits of grading Zone, I, II, or III of Table .
- Marble dust shall be obtained by crushing marble. Its grading shall fall within the limits of Grading Zone IV of Table below. Grading of Marble dust for use in Mortar shall be as per following table.

IS Sieve	Percentage Passing
10 mm	100
4.75 mm	95-100

2.36 mm	95-100
1.18 mm	90-100
600 micron	80-100
300 micron	15-50
150 micron	0-15

6.3.3.5 Sand for Masonry Mortar and for Plaster- Sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. Sand shall be hard durable, clean and free from adherent coating and organic matter and shall not contain the amount of clay, silt and fine dust more than specified as under. Deleterious Material: Sand shall not contain any harmful impurities such as iron, pyrites, alkalis, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shale in such form or in such quantities as to affect adversely the hardening, strength or durability of the mortar.

The maximum quantities of clay, fine silt, fine dust and organic impurities in the sand / Marble dust shall not exceed the following limits:

Clay, fine silt and fine dust when determined in accordance within IS 2386 (Part II). In natural sand or crushed gravel sand and crushed stone sand - Not more than 5% by mass

Organic impurities when determined in accordance with IS 2386 (Part II) - Colour of the liquid shall be lighter than that indicated by the standard specified in IS 2386 (Part II).

Grading of sand for use in masonry mortar shall be conforming to IS 216 (Table below).

Grading of sand for use in masonry mortar		Grading of sand for use in plaster	
IS Sieve Designation	Percentage passing by mass	IS Sieve Designation	Percentage passing by mass
10 mm	100	10 mm	100
4.75 mm	100	4.75 mm	95 to 100
2.36 mm	90 to 100	2.36 mm	95 to 100
1.18 mm	70 to 100	1.18 mm	90 to 100
600 micron	40 to 100	600 micron	80 to 100
300 micron	5 to 70	300 micron	20 to 65
150 micron	0 to 15	150 micron	0 to 50

Note: For crushed stone sands, the permissible limit on 150 micron IS Sieve is increased to 20%, this does not affect the 5% allowance as per IS 2386 (Part 1).

6.3.3.6 Bulking: Fine aggregate, when dry or saturated, has almost the same Volume but dampness causes increase in volume. In case fine aggregate is damp at the time of proportioning the ingredients for mortar or concrete, its quantity shall be increased suitably to allow for bulkage, which shall be determined by the method prescribed in Appendix 'D' of Chapter 3.0 Table 3.3 gives the relation between moisture content and percentage of bulking for guidance only.

6.3.3.7 Bulking of fine aggregates/sand (field methods)

Two methods are suggested for determining the bulking of sand/fine aggregate. The procedure may be suitably varied, if necessary. Both depend on the fact that the volume of inundated sand/fine aggregate is the same if the sand/fine aggregate were dry.

Method -1: Put sufficient quantity of sand loosely into a container until it is about two-third full. Level off the top of the sand and push a steel rule vertically down through the sand at the middle to bottom, measure the height. Suppose this is 'X' cm.

Empty the sand out of the container into another container where none of it is lost. Half fill the first container with water. Put back about half the sand and rod it with a steel rod, about 6 mm in diameter, so that its volume is reduced to a minimum. Then add the remainder and level the top surface of the inundated sand. Measure its depth at the middle with the steel rule. Suppose this is 'Y' cm.

The percentage of bulking of the sand due to moisture shall be calculated from the formula:

$$\text{Percentage bulking} = (X/Y - 1) \times 100$$

Method-2: In a 250 ml measuring cylinder, pour the damp sand, consolidate it by staking until it reached the 200 ml mark.

Then fill the cylinder with the water and stir the sand well (the water shall be sufficient to submerge the sand completely). It will be seen that the sand surface is now below its original level. Suppose the surface is at the mark of Yml, the percentage of bulking of sand due to moisture shall be calculated from the formula.

$$\text{Percentage bulking} = (200/Y - 1) \times 100$$

Moisture content % age	Bulking % age (by volume)
2	15
3	20
4	25
5	30

6.3.3.8 Stacking: Fine aggregate shall be so stacked as to prevent dust and foreign matter getting mixed up with it as far as practically possible. Marble dust in dry condition shall be collected in bags and properly staked so as not to form lumps, suitable arrangements shall be made to protect it from moisture similar to those adopted for stacking of cement bags.

6.3.3.9 Measurements: As the fine aggregate bulks to a substantial extent when partially wet, measurements shall be taken when the stacks are dry or appropriate allowance made for bulking.

6.3.4 BROKEN BRICK (BURNT CLAY) FINE AGGREGATE

6.3.4.1 Broken Brick (Burnt Clay) Fine Aggregate, also known as Surkhi, shall be made by grinding well burnt (but not under or over burnt) broken bricks as specified in IS 3068-1986. It shall not contain any harmful impurities, such as iron pyrites, salts, coal, mica, shale or similar laminated or other materials in such form of quantity as to adversely affect hardening, strength, durability or appearance of the mortar.

6.3.4.2 The maximum quantities of clay, fine silt, fine dust and organic impurities in surkhi (all taken together) shall not exceed five per cent by weight. The particle size grading of surkhi for use in lime mortars shall be within the limits specified in Table below

IS Sieve Designation	Percentage passing (by wt)
4.75 mm	100
2.36 mm	90-100
1.18 mm	70-100
600 microns	40-100
300 microns	5-70
150 microns	0-15

6.3.4.3 Stacking: Surkhi shall be stacked on a hard surface or platform so as to prevent the admixture of clay, dust, vegetation and other foreign matter. It shall be also protected from rain and dampness and kept under adequate coverings.

6.3.4.4 Measurements: Surkhi shall be measured in regular stacks in cubic metres. Alternatively, it may be measured by weight when supplied in bags.

6.3.5 FLY ASH

Fly ash is finely divided residue resulting from the combustion of pulverized coal in boilers. Fly ash is the pulverized fuel ash extracted from the flue gases by any suitable process such as cyclone separation or electrostatic precipitation. The ash collected from the bottom of boilers is termed as bottom ash. Fly ash is finer than bottom ash. Siliceous fly ash (ASTM Class F) containing calcium oxide less than 10% by mass is normally produced from burning anthracite or bituminous coal and possesses pozzolanic properties. Calcareous fly ash (ASTM Class C) is produced by burning lignite or sub-bituminous coal and contains calcium oxide more than 10% by mass; the content could be as high as 25%. This fly ash has both hydraulic and pozzolanic properties. It shall be clean and free from any contamination of bottom ash, grit or small pieces of pebbles. It is obligatory on the part of supplier/ manufacture that the fly ash conforms to the requirements if mutually agreed upon and shall furnish a certificate to this effect to the purchaser or his representative.

6.3.5.1 Characteristics: The physical requirements of fly-ash shall be as specified in Annexure 'E' as given below. The chemical properties of fly ash shall be as per IS 3812 (part 1 and 2) depending on the usage.

APPENDIX 'E': PHYSICAL REQUIREMENTS OF FLY ASH (Clause 3.1.5 and 3.1.5.1)

Sr. No	Characteristics Requirement of Fly Ash	For use as Pozzolana	For use as admixture in Cement Mortar and
1	2	3	4
(i)	Fineness- Specific surface in m ² /kg by Blaine's permeability method, min	320	200

(ii)	Lime reactivity – average compressive strength in N/mm^2 Min	4.5	-
(iii)	Compressive strength at 28 days in N/mm^2	Not less than 80 per cent of the strength of corresponding mortar cubes.	-
(iv)	Soundness of autoclave test expansion of specimens, per cent, max	0.8	0.8
(v)	Particles retained on 45 micron IS sieve (wet sieving) in percent maximum	34	50

6.3.5.2 Stacking: Fly ash shall be protected from dirt collecting on it.

6.3.5.3 Measurements: Fly ash shall be measured in regular stacks in cubic metres. Alternatively, it may be measured by weight when supplied in bags.

6.3.6 GROUND GRANULATED BLAST FURNACE SLAG FOR USE IN CEMENT

Blast furnace slag is a non-metallic product consisting essentially of glass containing silicates and aluminosilicates of lime and other bases, which is developed simultaneously with iron in blast furnace. Granulated blast furnace slag is obtained by further processing the molten slag by rapidly chilling or quenching with water or steam. It is granulated blast furnace slag duly ground so as to meet the requirements of this standard.

The properties and specifications shall be conformed with IS 16714:2018.

Chemical Properties Reference IS 16714: 2018 Ground Granulated Blast Furnace Slag for Use in Cement, Mortar and Concrete – Specifications Table 1 Chemical Requirements of GGBS (Clause 5.1)			
i)	Manganese oxide (MnO), Max	5.5	IS 4032
ii)	Magnesium oxide (MgO), Max	17	IS 4032
iii)	Sulphide sulphur (S), Max	2	IS 4032
iv)	Sulphate (as SO_3), Max	3	IS 4032
v)	Insoluble residue, Max	3	IS 4032
vi)	Chloride content, Max	0.1	IS 4032

vii)	Loss on ignition, Max	3	IS 4032
viii)	(CaO+MgO+1/3AlO3) / (SiO2 +2/3 AlO3) Min	1	IS 4032
ix)	(CaO+MgO + Al2 O3) / SiO2 Min	1	IS 4032
x)	(CaO+CaS+1/2MgO+Al2 O3) /SiO2 Min	1.5	IS 4032
Physical Properties Reference IS 16714: 2018 Ground Granulated Blast Furnace Slag for Use in Cement, Mortar and Concrete – Specifications Table 2 Chemical Requirements of GGBS (Clause 5.1)			
SI No.	Constituent	Requirement	Method of Test, Ref to
i)	i) Fineness, m2 /kg, Min	320	See Note 1 in reference code
ii)	Slag activity index		See Note 2 in reference code
	a) 7 days	Not less than 60 percent of control OPC 43 Grade cement mortar cubes	
	b) 28 days	Not less than 75 percent of control OPC 43 Grade cement mortar cubes	
Please refer to relevant codes for more clarity			

6.4 PREPARATION OF MORTARS AND ITS GRADE

6.4.1 GRADE OF MASONRY MORTAR

The grade of masonry mortar will be defined by its compressive strength in N/mm² at the age of 28 days as determined by the standard procedure detailed in IS 2250.

For proportioning the ingredients by volume, the conversion of weight into volume shall be made on the following basis:

- Burnt Clay Pozzolana 860 Kg/cum
- Coarse Sand (dry) 1280 kg/cum
- Fine sand (dry) 1600 kg/ cum
- Fly Ash 590 kg/ cum
- GGBS

For details of grades and criteria for selection of Masonry mortars see Appendix 'F'.

APPENDIX F - CRITERIA FOR SELECTION OF MASONRY MORTARS (Clauses 3.2.0, 3.2.0.1, 3.2.1.1)

6.4.1.1 The selection of masonry mortars from durability consideration will have to cover both the loading and exposure condition of the masonry.

6.4.1.2 In case of masonry exposed frequent to rain and where there is further protection by way of plastering or rendering or other finishes, the grade of mortar shall not be less than 0.7 MM but shall preferably be of grade MM2. Where no protection is provided, the grade of mortar for external wall shall not be less than MM2.

In case of load bearing internal walls, the grade of mortar shall preferably be MM 0.702 or more for high durability but in no case less than MM 0.5.

In the case of masonry work in foundations laid below damp proof course, the grade of mortar for use in masonry shall be as specified below.

- a) Where soil has little moisture, masonry mortar of grade not less than MM 0.7 shall be used.
- b) Where soil is very damp, masonry mortar of grade preferably MM 2 or more shall be used. But in no case shall the grade of mortar be less than MM 2.

6.4.1.3 For masonry in building subject to vibration of machinery, the grade of mortar shall not be less than MM 3.

6.4.1.4 For parapets, where the height is greater than thrice the thickness, the grade of masonry mortar shall not be less than MM3. In case of low parapets the grade of mortar shall be the same as used in the wall masonry.

6.4.1.5 The grade of mortar for bedding joints in masonry with large concrete blocks shall not be less than MM 3.

6.4.1.6 The compressive strength shall be determined in accordance with the procedure given in IS 2250.

- (i) While mixing the pozzolanic material like fly ash/GGBS in mortars Ordinary Portland cement only shall be used.

Grade of Masonry Mortar (IS 2250) (Clause 3.2.0)

Sl. No.	Grade	Compressive strength at 28 days in N/mm ²	Cement	Pozzolana (Fly Ash)	Sand
1 2	MM 0.7	0.7 to 1.5	1 1	-- 0.4*	8 10
3 4	MM 1.5	1.5 to 2.0	1 1	-- 0.4*	7 8.75
5 6 7	MM 3	3.0 to 5.0	1 1** 1	-- 0.21 0.4*	6 4.2 7.5
8 9 10	MM 5	5.0 to 7.5	1 1 1	-- 0.4 0.4	5 6.25 5
11 12 13 14	MM 7.5	7.5 & above	1 1** 1 1	0.2 0.4	4 2.1 3 3.75

Note:

* Pozzolana of minimum lime reactivity of 4 N/MM2

** This ratio by volume correspondence approximately to cement pozzolana ratio of 0.8:0.2 by weight. In this case, only ordinary Portland cement is to be used (see IS 269). Specifications for ordinary rapid hardening and low heat Portland Cement (Third revision)

6.4.2 CEMENT MORTAR

6.4.2.1 This shall be prepared by mixing cement and sand with or without the addition of pozzolana in specified proportions as per Appendix 'F'.

6.4.2.2 Proportioning: Proportioning on weight basis shall be preferred taking into account specific gravity of sand and moisture content. Boxes of suitable size shall be prepared to facilitate proportioning on weight basis. Cement bag weighting 50 kg shall be taken as 0.035 cubic metres. Other ingredients in specified proportion shall be measured using boxes of size 40 x 35 x 25 cm. Sand shall be measured on the basis of its dry volume in the case of volumetric proportioning.

6.4.2.3 Mixing: The mixing of mortar shall be done in mechanical mixers operated manually or by power as decided by PMC/Employer. The PMC/Employer may, however, permit hand mixing at his discretion taking into account the nature, magnitude and location of the work and practicability of the use of mechanical mixers or where item involving small quantities are to be done or if in his opinion the use of mechanical mixer is not feasible. In cases, where mechanical mixers are not to be used, the contractor shall take permission of the PMC/Employer in writing before the commencement of the work.

(a) Mechanical Mixing: Cement and sand in the specified proportions shall be mixed dry thoroughly in a mixer. Water shall then be added gradually and wet mixing continued for at least three minutes. Only the required quantity of water shall be added which will produce mortar of workable consistency but not stiff paste. Only the quantity of mortar, which can be used within 30 minutes of its mixing shall be prepared at a time. Mixer shall be cleaned with water each time before suspending the work.

(b) Hand Mixing: The measured quantity of sand shall be levelled on a clean masonry platform and cement bags emptied on top. The cement and sand shall be thoroughly mixed dry by being turned over and over, backwards and forwards, several times till the mixture is of a uniform colour. The quantity of dry mix which can be used within 30 minutes shall then be mixed in a masonry trough with just sufficient quantity of water to bring the mortar to a stiff paste of necessary working consistency.

6.4.2.4 Precautions: mortar shall be used as soon as possible after mixing and before it begins to set, and in any case within half hour, after the water is added to the dry mixture.

6.4.3 CEMENT FLY ASH SAND MORTAR

6.4.3.1 This shall be prepared by mixing cement, fly ash and sand in specified proportions. Mixing shall be done in a mechanical mixer (operated manually or by power) unless otherwise permitted by the PMC/Employer in writing. The PMC/Employer may, however, permit hand mixing at his discretion, taking into account the nature, magnitude and location of the work and practicability of the use of mechanical mixer or where items involving small quantities are to be done or if in his opinion the use of mechanical mixer is not feasible. In case, where mechanical mixer is not to be used, the contractor shall take permission of the PMC/Employer in writing before the commencement of the work.

6.4.3.2 Proportioning: Proportioning on weight basis shall be preferred taking into account specific gravity of Fly Ash, sand and moisture content. Boxes of suitable size shall be prepared to facilitate proportioning on weight basis. Cement bag weighting 50 kg shall be taken as 0.035 cubic metres. Other ingredients in the specified proportions shall be measured using boxes of suitable sizes. Sand and fly ash shall be measured on the basis of their dry volume in the case of volumetric proportioning.

6.4.3.3 Mixing

(a) Mechanical Mixing: Sand and fly ash in the specified proportions shall be mixed dry in a mixer and then the specified quantity of cement shall be added and mixed dry thoroughly. Water shall then be added gradually and wet mixing continued for at least one minute. Water shall be just sufficient to bring the mortar to the consistency of a workable paste. Only the quantity of mortar which can be used within 30 minutes of its mixing shall be prepared at a time.

(b) Hand Mixing: The measured quantity of sand and fly ash shall be mixed dry on a clean masonry platform before adding specified quantity of cement to it. The resulting mixture of cement, sand and fly ash shall then be mixed thoroughly being turned over and over, backward several times till the mixture is of a uniform colour. The quantity of dry mix which can be used within 30 minutes shall then be mixed in a clean watertight masonry trough with just sufficient quantity of water, to bring the mortar to a stiff paste of necessary working consistency.

6.4.3.4 Precautions: Shall be same as specified in 6.4.2.4

7 BLOCK MASONRY WORKS

7.1 SOLID CONCRETE BLOCK WORK

7.1.1 SCOPE

These specifications cover the use of Concrete Block Masonry for the structural / non structural purposes.

7.1.2 GENERAL

The provision of the latest Indian Standards listed below form part of these specifications:

All relevant Standards as specified elsewhere in this Volume are also applicable.

1.	IS 269	Specification for ordinary and low heat Portland cement
2.	IS 383	Specification for coarse and fine aggregates from natural sources for concrete.
3.	IS 455	Specification for Portland slag cement
4.	IS 456	Code of Practice for plain and reinforced concrete.
5.	IS 2185	(Part I) Solid cement concrete blocks.
6.	IS 2572	Code of practice for construction of hollow concrete block masonry.
7.	IS 2645	Specification for integral waterproofing compound.
8.	IS 9103	Specification for admixtures for concrete.

7.1.3 MATERIAL

7.1.3.1 Cement

Shall be as per 3.4.1

7.1.3.2 Aggregates

Aggregates shall conform to IS 383. Grading shall be as indicated in IS 383. The aggregates used in the manufacture of block shall be clean and free from all deleterious matter and shall conform to the requirements of IS:383-1970. All the properties and specifications shall be as per 3.3 IS.

7.1.3.3 Water

Water conforming to IS 456 and as approved by the EIC shall be used.

7.1.3.4 Admixtures

Additives or admixtures may be added to the cement or concrete mix conforming to the IS specifications. Admixtures shall be chloride free and melamine polymer based.

Other additives or admixtures not being governed by Indian Standards shall be tested and checked that the same are not detrimental to durability. However, any addition shall only be after approval of the EIC.

7.1.3.5 Fly Ash

Fly Ash conforming to IS: 3812-1981 may be used for part replacement of fine Aggregate up to a limit of 20% or as directed by the Structural Consultant

7.1.3.6 GGBS

GGBS conforming to IS:16715-2018 may be used for replacement of fine aggregate as directed by PMC/Employer.

7.1.4 MANUFACTURE

7.1.4.1 Concrete blocks may be hollow (open or closed cavity) or solid and shall be referred to by its nominal dimension. The term nominal dimension includes the thickness of the mortar joint. All specifications of solid concrete blocks including specifications for actual dimensions, tolerances, sizes, shapes and webs, grades of blocks etc. shall conform to IS : 2185. Blocks may be manufactured either at construction site or in factory on a central casting platform using steel moulds with or without surface vibration for compaction of cement concrete.

7.1.4.2 Mould: - Moulds shall be fabricated using mild steel plates and mild steel angles for stiffening the plates. The mould shall be either fixed type (box with four side walls fixed at corners, and top and bottom open) or split type. Split type may be either individual or gang mould. Where the compaction of the concrete is done manually, the mould may be either fixed type or split type. When the compaction of the blocks is done with surface vibrator, the mould shall be only split type (individual or gang mould).

7.1.4.3 Concreting: Concrete mix used for blocks shall be pre-designed to give a minimum crushing strength. Concrete shall be mixed in the mechanical mixer. Blocks shall be moulded, laid and compacted with automatic machines table vibrator. Care shall be taken to see that the mix mould is properly filled up. Block shall be protected until they are sufficiently hardened to permit handling without damage. The cement concrete mix for concrete masonry blocks shall not be richer than one part by volume of cement to 9 parts by volume of combined fine and coarse aggregates and shall not be leaner than one part by volume of cement to 13 parts by volume of combined fine and coarse aggregates.

In case of blocks where compaction is done manually, concrete mix of medium Consistency (10-12 mm slump) shall be used in order to enable proper compaction and de-moulding. The consistency of the mix should be such that it may cohere when compressed in the hand without free water being visible. In case of blocks where compaction is done by external vibrator, concrete mix of very low consistency (zero slumps) shall be used in order to vibrate and compact the concrete under pressure.

7.1.4.4 Mixing: - Concrete shall normally be mixed in a mechanical mixer unless otherwise permitted by PMC/Employer. In case of hand mixing 10% extra cement shall be used without any extra payment. Mixing shall be continued until there is a uniform distribution of the materials, and the mass is uniform in colour and consistency.

7.1.4.5 De-moulding shall be done 5 to 10 minutes after compaction. In case of fixed type mould it shall be pulled up with side handles while pressing down the block with the plate at top with thumb. In case of split type mould, the sides shall be removed first and the partition plates (gang mould) shall be pulled up subsequently.

After de-moulding, the blocks shall be protected until they are sufficiently hardened to permit handling without damage.

7.1.4.6 Curing and Drying

Blocks shall be cured in the curing yard by keeping them continuously moist for at least 14 days. Steam-cured blocks shall be preferred. Cured blocks shall be allowed to dry for a period of 4 weeks before being used. The blocks shall be allowed to complete their initial shrinkage before they are laid in the wall.

7.1.5 PHYSICAL REQUIREMENTS

All blocks shall be sound and free of cracks or other defects. For exposed construction face or faces shall be free of chips, or other imperfections, and the overall dimensions of the blocks shall be in accordance to tolerance as specified. Minimum compressive strength shall be as per table 2 below. maximum permissible water absorption shall not exceed the limit specified in I.S.:2185, dimensional variations shall conform to I.S. 2185.

The minimum compressive strength at 28 day being the average of eight blocks, and the minimum compressive strength at 28 days of individual blocks, when tested in the manner described in Appendix B, of IS:12440-1988, shall be as prescribed in Table .

COMPRESSIVE STRENGTH OF CONCRETE STONE MASONRY BLOCKS

Class Designation	Minimum average Compressive Strength of blocks (N/mm²)	Minimum strength of individual blocks N/mm²
5	5.0	3.5
6	6.0	4.2
7	7.0	5.0
9	9.0	6.3
10	10.0	7.5

For 100 mm wide blocks (for 100 mm thick walls), the minimum strength may be 3.5 N/mm²

7.1.6 TESTING

Tests as indicated in Appendices A to F of IS 2185 shall be conducted on samples of units selected according to the sampling procedure given here under to ensure conformity with the physical requirements as specified.

7.1.7 SAMPLING

A sample of 20 blocks shall be taken from every consignment of 5000 blocks or part thereof of the same size and same batch of manufacture. From these samples, the blocks shall be taken at random for conducting the test.

The blocks shall be taken at regular intervals during the course of work, preferably while being loaded or unloaded. In case samples are to be taken from the stacks, blocks shall be taken at random from across the top of the stacks, the sides accessible and from the interior of the stacks.

The blocks shall be kept under cover and protected from extreme conditions of temperature, relative humidity and wind until they are required for test. The test shall be conducted as soon as the sample has been taken.

7.1.8 NUMBER OF TESTS

All the 20 blocks shall be checked for dimensions and inspected for visual defects. Out of the 20 blocks, 3 blocks shall be subjected to the test for block density, 8 blocks to the test for compressive strength, 3 blocks to the test for water absorption and 3 blocks to the test for drying shrinkage and later to the test for moisture movement. The remaining 3 blocks shall be reserved for retest for drying shrinkage and moisture movement if a need arises.

Blocks shall be approved if requirements of conditions mentioned in 11.2 to 11.5 (as given below) of IS 2185 (Part I) are satisfied.

- The number of blocks with dimensions outside the tolerance limit and / or with visual defects, among those inspected shall not be more than two.
- For Block density and compressive strength, the mean value determined shall be greater than or equal to the minimum limit specified in Table 2 of IS 2185 (Part I) and reproduced as Table 27 of

Annexure.

- c) For drying shrinkage and moisture movement, all the test specimens shall satisfy the requirements of the test. If one of more specimens fails to satisfy the requirements, the remaining 3 blocks shall be subjected to these tests. All blocks shall satisfy the requirements. Drying shrinkage shall not exceed 0.1 percent.
- d) For water absorption, the mean value determined shall not be more than 10 percent by mass

7.2 HOLLOW AND SOLID CONCRETE BLOCK MASONRY

Hollow and solid concrete blocks- Shall conform to the requirements of IS: 2185--1979.

Specification for hollow and solid concrete blocks except with regard to the mix of cement concrete and sizes of aggregates shall be as indicated. Hollow blocks shall be sound, free from cracks, broken edges, honey combing and other defects that would interfere with the proper placing of block or impair the strength or performance of construction.

Concrete Block-hollow (open or closed cavity) or solid shall be referred to by its nominal dimensions. The nominal dimensions of concrete block shall be, as follows:

Length 400,500 or 600 mm

Height 200 or 100 mm

Width 50,75,100, 150, 200, 250 or 300mm.

In addition, block shall be manufactured in half lengths of 200, 250 or 300 mm to correspond to the full lengths. The maximum variation in the length of the units shall be not more than ± 5 mm and maximum variation in height and width of unit, not more than ± 3 mm.

7.2.1 WORKMANSHIP

7.2.1.1 In total dry climate top and sides may be slightly moistened to avoid absorption of water from mortar.

7.2.1.2 Joints shall not be bigger than 10mm and will be perfectly horizontal and vertical. Joints shall be raked 10mm deep while mortar is wet.

7.2.1.3 Cut blocks shall not be used. Special solid pre-cast blocks at site shall be cast well in advance to be used as spacers and to adjust breaking of vertical joints.

7.2.1.4 Cracks in block masonry are due to shrinkage or expansion of blocks or due to settlement, thermal expansion or changes in moisture content in the structural members enclosing the block walls. The following measures are recommended to prevent formation of cracks.

- a) While curing, the block masonry should be lightly sprinkled with water and not made excessively wet.
- b) Expansion joints shall be provided in walls exceeding 30m in length.
- c) Reinforcement should be provided in the bed joints in block work, one course above and course below windows and above doors in order to distribute the shrinkage/ temperature stresses occurring at the corners of openings, more uniformly throughout the walls.
- d) R.C.C, Post and Transoms shall be provided and per the detail drgs in all Masonry and as mentioned in BOQ. The gap between the top most layer of block and the soffit of the beam shall be packed by lightly hammering flat pieces of Shahabad / Kota tiles and then the gaps will be covered by weld mesh before closing them by cement plaster. The PVC mesh will be extended at least 150 mm on the R.C.C. beam and 150 mm on block masonry and nailed to them with strong nails.
- e) Provisions for door and window frames: - A course of solid concrete block masonry shall be provided under door and window openings (or a 10cm thick pre-cast concrete sill block under windows). The solid course shall extend for at least 30cm beyond the opening on either side. For jambs of very large doors and windows either solid units are used, or the hollows shall be filled in with concrete of mix 1:3:6.

f) Provisions for Roof / ceiling: - The course immediately below the roof slab shall be built with solid blocks: The top of the roof course shall be finished smooth with a layer of cement and coarse sand mortar 1:3, 10mm thick and covered with a thick coat of white wash or crude oil, to ensure free movement of slab.

g) Intersecting walls: - When two walls meet or intersect and the courses are to be laid up at the same time, a true masonry bond between at least 50% of the units at the intersection is necessary. When such intersecting walls are laid up separately, pockets with 20mm maximum vertical spacing shall be left in the first wall laid. The corresponding course of the second wall shall be built into these pockets. Fixtures, fittings, etc. shall be built into the masonry in cement and coarse sand mortar 1:3 while laying the blocks where possible. Hold fasts shall be built into the joints of the masonry during laying. Holes, chases, sleeves, openings, etc of the required size and shape shall be formed in the masonry with special blocks while laying, for fixing pipes, service lines, passage of water etc. After service lines, pipes etc are fixed, voids left, if any, shall be filled up with cement concrete 1:3:6 (1 cement 3 coarse sand: 6 stone aggregate 20mm nominal size) and neatly finished.

7.2.2 SCAFFOLDING

Scaffolding shall be double and shall be erected with steel sections or pipes of adequate strength so as to be safe for construction operations. The contractor shall take all measures to ensure the safety of the work and working people. Any instructions of the PMC/Employer in this respect shall also be complied with. The contractor shall be entirely responsible for any damage to property or injury to persons resulting from ill erected scaffolding, defective ladders and materials or otherwise arising out of his default in this respect. Proper scaffolding shall be provided to allow easy approach to every part of the work. Overhead work shall not be allowed. Block work shall be carried out with double scaffolding only. Making holes of any kind for the purpose of supporting the scaffolding shall not be permitted. Railing Must be provided for safety purposes at all heights & levels. Contractor to ensure safety measures are followed as instructed.

7.2.3 MEASUREMENT

Hollow or solid cement concrete block work shall be measured in Sqm for the specified width.

7.2.4 RATES

Rates for concrete block masonry item shall include the following:

- a) Material and labour, for the completion of items as specified including any centring, shuttering, curing etc.
- b) Raking out of joints.
- c) Preparation of the tops and sides.
- d) Forming and preparing expansion, contraction or construction joints as detailed above or specified in the BOQ or drawings.
- e) Making holes, openings, etc. for outlets, embedding down take pipes, etc. wherever necessary during construction and finishing exposed surfaces as per instruction of the EIC.
- f) Curing and protection as specified.
- g) Making holes, openings, outlets, etc. embedding pipes, ends of beams, joints, slabs, trusses, sills, etc. whatever required during construction and neatly finishing the exposed surfaces and opening as per instructions of the EIC.
- h) RCC Post and Transoms as per BOQ

7.3 AUTOCLAVED AERATED BLOCKS / LIGHT WEIGHT BLOCK MASONRY**7.3.1 MATERIAL:**

The light weight block shall be of Siporex (India) manufacture or equivalent. The blocks shall have thickness of 200 mm, 150 mm, 100 mm for load bearing walls, partitions and cladding work, etc. The blocks shall have a maximum density of 640 kg / cu.m. or less.

7.3.1.1 Structural Strength requirement:

- a) Compressive Strength: The light weight concrete block shall have a minimum compressive strength of 35 kg / sq.cm.
- b) Bending Compression: 15 kg / sq.cm.

7.3.1.2 The mortar used for light weight concrete block shall be as specified in the Schedule of Items; Cement and water used in mortar shall conform to the quality as described in 'Concrete', whereas sand used for mortar shall be fine screened only. The light weight concrete block masonry should not be used below ground or in plinth. The block masonry work shall be built in stretcher course only.

7.3.1.3 The light weight concrete block wall or required thickness as described in Schedule of Items, shall be constructed with R.C.C. vertical and horizontal stiffeners, of required size at suitable intervals, as directed by the PMC/Employer, or as per drawing. R.C.C. and steel reinforcement shall be included in the rate and will not be paid separately. The masonry work shall be raised truly in plumb. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. The vertical joints should be not more than 12mm thick and shall be fully filled from the top with cement mortar without any void in masonry. All face joints shall be raked out to a minimum depth of 15 mm. by raking tool, during the progress of the work, when the mortar is still green, so as to provide proper key for the plaster or pointing. All fixtures, pipes, outlets of water, holdfasts, of doors, windows, which are required to be built into the block masonry, shall be embedded in mortar or cement concrete, as specified, in correct position, as the work proceeds and as directed by the PMC/Employer. After masonry work is over, the masonry shall be marked with date of construction, visible for inspection and curing.

7.3.2 CURING

All joints of block masonry shall be kept constantly moist by sprinkling water on all joints for a minimum period of seven days.

7.3.3 SCAFFOLDING

Same as described in 7.2.2.

7.3.4 MEASUREMENT

Light weight block masonry wall shall be measured in sq. Metres for a width of less than 200mm. For 200mm blocks the mode of measurement to be in cubic meters. All measurements to be correct to two places of decimal. All opening in masonry works for doors, windows, ventilators and any other opening shall be deducted to get net quantity of actual light weight concrete block masonry. No deduction is to be made for opening up to 0.1 m². No separate payment shall be made for extra work involved in making openings, chases in wall for electrical inserts, conduits, etc.

7.3.5 RATE

The rate quoted for block masonry shall include the cost of material, wastage, labour involved in all operations described above, including transportation, overheads, profits, cutting, tools, equipment,

necessary scaffolding, raking out joints to receive plaster, opening, cutting and chases in masonry for fixing doors, windows, ventilators, switch boxes, conduit, etc. and making good. Rate is also inclusive of making pillars, copings, ledges, projections, if any, and also to be inclusive of all operations for masonry work to be done at all levels.

8 PLASTERING**8.1 SCOPE**

These specifications cover the use of plastering for masonry and RCC work, pointing for brick and stone masonry work.

8.2 IS CODES

The provision of the latest revisions of the following IS codes shall form a part of this specification to the extent they are relevant.

IS: 269	Specification for ordinary rapid hardening and low heat Portland cement
IS: 712	Building Lines
IS: 1200 (Part XII)	Method of measurement of building and Civil Engg. Works - Plastering and Pointing
IS: 1542	Specification for sand for plaster
IS: 1630	Mason's Tools for Plaster work and pointing work.
IS: 1661	Code of practice for application of cement lime plaster finishes
IS: 10067	Material Constants for Building Works

Other I. S. Codes, not specifically mentioned here, but pertaining to plastering work, form part of these specifications.

8.3 GENERAL**8.3.1 CEMENT MORTAR**

Cement mortar shall have the proportion of cement to sand as specified and shall comply with relevant clauses of Cement Mortar specifications.

8.3.1.1 Cement

Shall be as per 3.4.1

8.3.1.2 Water

Shall be as per 6.3.1

8.3.1.3 Fine Aggregate

Shall be as per 6.3.3

8.3.2 SCAFFOLDING

Shall be as per 7.2.2.

8.3.3 TOOLS AND ACCESSORIES

Tools and accessories used in plaster work shall conform to IS: 1630. All tools shall be cleaned by scrapping and washing at the end of each day's work or after use. Metal tools shall be cleaned after

each operation. All tools shall be examined to see that they are thoroughly cleaned before plastering is begun.

8.3.4 PROGRAMME OF WORK IN RELATION TO PLASTERING

The programme of other building operations before, during and after plastering shall be according to the instructions contained in clause 9 of IS: 1661.

8.3.5 GENERAL PRECAUTION IN PLASTERING

All general precautions as specified in IS. 1661, Clause 9, shall be taken and preparation of the background shall be done as laid down in IS: 1661, Clause 13. Care shall be taken to see that other parts of the work or adjacent works are not damaged while plastering.

8.3.6 PREPARATORY WORK

All joints in the face work that is to be plastered shall be raked out to depth equal to not less than the width of the joints or as directed by the PMC/Employer. The raking shall be done taking care not to allow by chipping of masonry. In new work the raking out shall be done when the mortar in the joints is still green. Smooth surfaces of concrete, old plaster, etc. must be suitably roughened to provide necessary bond for the plaster. All dirt, soot, oil paint or any other material that might interfere with satisfactory bond shall be removed. In the case of stone masonry, scrubbing on the walls to receive the plaster shall not be more than 12 mm (1 ½"). The surface to be plastered shall be cleaned and scrubbed with fresh water and kept wet for 6 hours prior to plastering. It shall be kept damp during the progress of the work. The plastering shall not be commenced unless the preparatory work is passed in writing by the PMC/Employer.

In hand mixed mortar, cement and sand in the special proportions shall be thoroughly mixed dry on a clean impervious platform. Fresh and clean water as specified above shall be added gradually and thoroughly mixed to form a stiff plastic mass of uniform colour so that, each particle of sand shall be completely covered with a film of wet cement. The water cement ratio may be as under or as directed by the PMC/Employer.

Cement Ratio per 50 kg of cement	Sand	Water-Cement	Qty of Water (Litres)
1	1	0.25	12.5
1	1-1/2	0.28	19
1	2	0.3	15
1	2-1/2	0.35	17.5
1	3	0.4	20
1	4	0.53	26.5
1	5	0.6	30
1	6	0.7	35
1	8	0.9	45

Machine mixed mortar shall be prepared in an approved mixer. Water cement ratio shall be as per hand mixed mortar. The mortar so prepared shall be within 30 minutes of adding water should be used in the work. The mortar remaining unused after that period mortar which has partially hardened or is otherwise damaged shall not be re-tempered or remixed. It shall be destroyed or thrown away.

8.3.7 GAUGES

Patches of plaster 15cm x 15cm shall be put on about 3 m apart as gauges to ensure even plastering in one plane.

8.3.8 WORKMANSHIP

8.3.8.1 Plastering

In all plaster work the mortar shall be firmly applied with somewhat more than the required thickness and well pressed into the joints and on the surface and rubbed and levelled with a flat wooden rule to give required thickness. Long straight edges shall be freely used to give perfectly plane and even surface. All corners must be finished to their true angles or rounded as directed by the PMC/Employer. The surface shall be finished to plane or curved surface as shown on the plan or directed by the PMC/Employer and shall present a neat appearance. The mortar shall adhere to the masonry surface intimately when set and there should be no hollow sound when struck. Cement plastering should be done in squares or strips as directed. Plastering shall be done from top downward.

8.3.8.2 First or Backing Coat

The first coat of the specified thickness shall be applied as described above. The subsequent coat shall be applied after this coat has been allowed to set for 3 to 5 days depending upon weather conditions. The surface shall not be allowed to dry during this period.

8.4 PLASTERING TO CEILING

Projecting burrs of mortar formed due to the gaps at joints in shuttering shall be removed. The surface shall be scrubbed clean with wire brushes. In addition, concrete surface shall be poke marked with a pointed tool at spacing of not more than 50 mm centres, the pokes being made not less than 3 mm deep, to ensure a proper key for the plaster. The mortar shall be washed off and surface cleaned of all oil, grease etc., and well wetted before the plaster is applied.

Cement plaster to ceiling shall be 6 mm thick finished / not finished with a floating coat of neat cement and thick coat of lime wash on top of walls for bearing of slabs.

The plaster shall be applied over the cleaned and wetted surface of the wall. When the plaster has been brought to a true surface with the wooden straight edge it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 1 kg per Sqm. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the specifications described above shall apply.

8.5 SAND FACED PLASTER IN CEMENT MORTAR

8.5.1 BASE COAT

The base coat plaster shall be of cement mortar 1:4 or as specified in the BOQ. Waterproofing compound of approved make shall be added according to the makers' instructions to make the mortar waterproof.

The plaster with this mortar shall be laid as specified above with a thickness of not more than 12 mm for brick work and concrete surfaces, and 15 mm for rubble stone masonry. Keys shall be formed on the surface by thoroughly combing it with wavy horizontal lines about 12 mm apart and about 3 mm deep when the mortar is still plastic. The base coat shall be cured for not less than 2 days.

8.5.2 SAND. FACED TREATMENT

The cement mortar for sand faced plaster shall have washed Kharasalis or similar type of approved sand with slightly larger proportion of coarse material. The proportion of cement to sand shall be 1:4 or as specified in the BOQ. The water is added gradually to make the mixture homogeneous. The thickness of finishing coat shall not exceed 7 mm. After application, the surface should be finished with

a wooden flat, lined with cork and tapped gently to retain a coarse surface texture. When the finishing coat has hardened, the surface shall be kept moist continuously for 14 days.

8.5.3 GROOVES IN SAND FACE PLASTER

The grooves are to be to the required depth and width. They should be neatly finished with extreme care. All horizontal and vertical grooves should be in perfect line and level.

8.5.4 SCAFFOLDING

Shall be as per 7.2.2

8.6 ROUGH COAT CEMENT PLASTER WITH CEMENT MORTAR

8.6.1 BASE COAT

The first coat of plaster shall be of cement mortar of 1:4 mix and applied according to the relevant provisions of IS: 1661 Clause 14. 1. The finished thickness of the first coat shall be 12 mm for brick masonry or concrete surface and 15 mm for rubble stone masonry. The plaster shall be laid by throwing the mortar (by using a strong whipping motion) on the prepared surface with a trowel in a uniform layer, and pressed to form a good bond. The surface shall be roughened.

8.6.2 SECOND COAT

The second coat shall be the rough coat mixture consisting of aggregate, which may vary in size from 5 to 8 mm and may consist of specially graded mixture mixed with fine sand and cement. The proportion of cement to sand and aggregate shall be 1:1½:3. It shall be flung upon the first coat with large trowels to form an even protective coat. The second coat must be applied while the first coat is still soft and plastic. The work shall generally conform to clause 16.5 of IS: 166. The thickness of the coat shall be about 12 mm.

8.6.3 SCAFFOLDING

Shall be as per 7.2.2

8.7 MESH TO WALLS

8.7.1 PVC PLASTER MESH

PVC Plaster mesh should be made from Polypropylene products and should possess good chemical and heat resistance. They should be semi rigid with good impact strength, appearance and are easily welded. The thickness of mesh to be 0.9mm

8.7.2 100% VIRGIN POLYPROPYLENE FIBRES

The following are the general properties of the 100% Virgin Polypropylene fibres:

- a) Should provide inherent micro-reinforcement against shrinkage and intrinsic cracking.
- b) Should reduce rebound losses in plasters to 60-70%.
- c) Should improve impact resistance 3-4 times and should improve abrasion resistance by 30-40%.
- d) Should reduce permeability and thus protects interior paint in plasters.

Dosage for plasters: 100-125 g / 50 kg cement bag or as recommended by designer.

Mixing process: Mix directly in the concrete mixer @ 125 g / 50 kg bag of cement or 0.9 kg/m³.

For plastering applications dry mix with sand cement mortar before adding water.

8.8 GYPSUM PLASTER TO WALLS

GYPSUM UNIVERSAL PLASTER (Base coat), a gypsum based material in a handy application can be applied over any normal background in not more than one coat, depending on evenness or the background. Smooth finish and good impact strength are its virtue.

Gyplaster base coat plaster is a calcium sulphate hemihydrate plaster with additives including light weight aggregate to improve plasters handling workability and application. It attains early strength and is free from shrinkage cracks. The thickness of the plaster should be a maximum of 13 mm on uneven background but should not exceed 10 mm or less than 5 mm on a level and even background.

The setting time of plaster is approximately 30 minutes after the application, depending upon suction of background. The setting progresses evenly and gradually until the surface is hard enough to receive a final stroke of a trowel, at approximately 45 to 60 minutes.

The coverage is approximately 65 to 75 sq.m. per 1000 kg at 13 mm thickness.

For application of gyplaster, the wall is first marked vertically at 1220 mm centres, then checked with straight edge, or line (preferably aluminium square tube) centres to find the high spots which are used as guide for level to be set.

The background should be suitably wetted with a brush 5-10 minutes before plastering to displace the trapped air and for a good plaster contact with the surface. Four points (by putting plaster with flat surface) are fixed in level and plumb to each corner of the wall to determine the thickness of the plaster required to be done.

40 mm wide strips of plaster are fixed. Then the points are applied vertically, in level and plumb of both ends of the wall.

These vertical strips are then made with plaster at even 1220 (or 1550 mm) centres on the entire area of the wall, to ensure level and plumb of the strips, to be in line.

The plaster is applied to surface of the wall with a trowel to required thickness and finish the surface by setting straight edge (sq. tube) horizontally by them placing on the vertical strips already fixed above, with firm pressure.

A tight coat is applied then turned back with the same batch material to fill out to required thickness. A featheredge should be used to straighten the plaster to a reasonable plane, whilst at the same time filling in any slacks or hollows when the plaster has stiffened sufficiently, further ruling out the feather edge is necessary to achieve a flat surface.

As the plaster stiffens progressively, further flattening and paring should be carried out with a spatula. When the plaster is sufficiently formed, the surface should be soaked lightly with a sponge float and light application of water if necessary to raise the flat and bring the surface to a suitable condition for finishing.

Closing in with the trowel should commence as soon as plaster starts to set, followed by a final trowel at the appropriate time.

Overpolishing should not be done at any cost.

Decoration and final finish should be delayed until the plaster work has dried out thoroughly.

Precautions:

- a. Tools and water used in mixing must be clean and free from set plaster and other impurities.
- b. Set plaster shorten the setting time and thus reduces the strength of plaster which sets.

- c. Surfaces should be protected from weather and should be reasonably wetted 5-10 minutes before plastering so that the plaster holds on the background satisfactorily.
- d. Fittings and plugging of all kinds should be done before proceeding to plaster.
- e. Openings, chases or other apertures for cable conduits and other's should be cut before plastering.
- f. Background to be plastered should be thoroughly brushed with broom to remove dust and loose mortar.
- g. Once a mix has started to set, it should not be retempered neither should be a fresh gauging be mixed with an old one.

Background surface should be reasonably dry and protected from the weather. The suitability of a particular background for plastering should be considered in relation to its length, suction, bonding properties, shrinkage or thermal movement characteristics, water and soluble salt content. The high suction of certain backgrounds (like concrete block masonry) should be adjusted by sprinkling water.

Plaster is not supposed to isolate dampness and this is not suitable for use in continuously damp or humid conditions. During application of Gyplaster in hot or dry conditions, care should be taken to ensure that rapid loss of water is avoided. The reason is that Gyplaster requires a proportion of the mixing water in order to set and achieve full strength. If the water is dried off too rapidly then the strength of the plaster will be impaired. Once set and fully dry, it is suitable for use in situation where the inside temperature is 50 de. C maximum.

Universal plaster attains early strength during the drying process and the plaster work does not suffer from inherent shrinkage cracks. Whilst the finished surface can be intended by impact, the natural resilience of set plaster prevents more serious damage.

Tubular service conduits should be chased into the background wherever possible. The following precautions should be taken in order to minimise any risk of subsequent plaster cracking or rust staining over service runs.

- a) Conduit of minimum permissible dimensions should be used.
- b) High spots in the background should be chiselled if possible.
- c) The undercoat plaster thickness specified should be sufficient to cover the extreme protrusions of the conduit by at least 5 mm.
- d) Service routes should avoid door frames, ground, etc.
- e) Service piping, conduits, fixing clips and other metallic objects should be adequately protected by galvanizing, painting or applying a thicker layer of lacquer in order to protect if from rusting.
- f) At junctions of different materials (like concrete blocks and RCC columns/ beams) a fibre mesh shall be applied prior to the application of the plaster to avoid cracks at a later date.

Gyplaster universal shall be mixed in a clean mixing bucket using clean water. Plastic buckets can be used to avoid rust staining from metal containers

8.9 MEASUREMENTS

8.9.1 Length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal.

Thickness of the plaster shall be exclusive of the thickness of the key i.e. grooves, or open joints in brick work.

The measurement of wall plaster shall be taken between the walls or partitions (the dimensions before the plaster shall be taken) for the length and from the top of the floor or skirting to the ceiling for the height. Depth of coves or cornices if any shall be deducted.

The following shall be measured separately from wall plaster.

- a. Plaster bands 30 cm wide and under
- b. Cornice beadings and architraves or architraves moulded wholly in plaster.

- c. Circular work not exceeding 6 m in radius.

Plaster over masonry pilasters will be measured and paid for as plaster only.

Exterior plastering at all heights shall be measured together. Patch plastering (in repairs) shall be measured as plastering new work, where the patch exceed 2.5 Sqm. extra payment being made for preparing old wall, such as dismantling old plaster, raking out the joints and cleaning the surface. Where the patch does not exceed 2.5 Sqm in area it shall be measured under the appropriate item under sub head 'Repairs to Buildings.'

8.9.2 Deductions in measurements, for opening etc. will be regulated as follows:

No deduction will be made for openings or ends of joists, beams, posts, girders, steps etc. up to 0.5 Sqm in area and no additions shall be made either, for the jambs, soffits and sills of such openings. The above procedure will apply to both faces of wall. Deduction for opening exceeding 0.5 Sqm but not exceeding 3 Sqm each shall be made for reveals, jambs, soffits sills, etc. of these openings.

- a) When both faces of walls are plastered with same plaster, deductions shall be made for one face only.
- b) When two faces of walls are plastered with different types of plaster or if one face is plastered and other is pointed or one face is plastered and other is unplastered, deduction shall be made from the plaster or pointing on the side of the frame for the doors, windows etc. on which width of reveals is less than that on the other side but no deduction shall be made on the other side. Where width of reveals on both faces of wall are equal, deduction of 50% of area of opening on each face shall be made from area of plaster and/or pointing as the case may be.
- c) For opening having door frame equal to or projecting beyond thickness of wall, full deduction for opening shall be made from each plastered face of wall.

For opening exceeding 3 Sqm in area, deduction will be made in the measurements for the full opening of the wall treatment on both faces, while at the same time, jambs, sills and soffits will be measured for payment.

In measuring jambs, sills and soffits, deduction shall not be made for the area in contact with the frame of doors, windows etc.

8.10 **RATE**

The rate shall include the cost of all labour and materials involved in all the operations described above.

- 8.10.1 Providing GI Chicken mesh 20 gauge or PVC mesh (whichever is mentioned in the BOQ), over lapping to a width of 150 mm at the junctions of masonry and concrete works on either side and including tying in position by using suitable nails / clamps / screws and as directed etc. complete at all levels
- 8.10.2 Forming of drip mould/ bands, grooves of sizes as required etc., wherever grooves are to be provided horizontally/ vertically for in accordance with the drawings.
- 8.10.3 Cost of All material and labour
- 8.10.4 Hacking concrete surfaces to be plastered or rendered
- 8.10.5 Preparation of surfaces by raking out joints, wetting the surface etc.,
- 8.10.6 Work at all heights, levels and situations.
- 8.10.7 Washing floors, cleaning glass and leaving premises clean and tidy after the plastering is done. Disposing off the debris outside the site
- 8.10.8 Curing the same.
- 8.10.9 Providing necessary scaffolding, ladder, platform for any height and depth and removing the same after the work is completed
- 8.10.10 Neat finishing of junctions of plaster and skirting
- 8.10.11 Screening and washing approved fine aggregates

9 PAINTING**9.1 SCOPE**

These specifications cover the use of paints for the plastered and concrete surfaces. It also includes the painting of wood and metal surfaces. The paint to be low VOC. Conventional paints contain Volatile Organic Compounds (VOC), which are petroleum-based solvents that evaporate from paint films while the paint is drying. These compounds are the unpleasant solvent fumes that may trigger respiratory reactions including asthma and breathing discomfort, when using conventional paints. They also contribute to greenhouse gas emissions.

Traditional oil based paints (also known as alkyd enamels) have a solvent level of approximately 50% or more. This means that for every four-litre can of enamel, two litres go straight into the atmosphere, compounding the "Greenhouse Effect". Conventional water-borne paints have a solvent level of around 7%, so obviously using water-borne paints is a far more environmentally responsible option.

Additives classified as VOC's are included to achieve some of the positive attributes of paint, such as good coverage, easy application and wash ability. The challenge for manufacturers, is delivering the quality of paint finish customers have come to expect, whilst reducing the overall environmental impact of each tin.

Low VOC paints, stains and varnishes use water as a carrier instead of petroleum-based solvents. As such, the levels of harmful emissions are lower than solvent-borne surface coatings. These certified coatings also contain no, or very low levels, of heavy metals and formaldehyde. The amount of VOC's varies among different "low-VOC" products, and is listed on the paint can or MSDS. Paints and stains, to meet EPA standards, must not contain VOC's in excess of 200 grams per litre. Varnishes must not contain VOC's in excess of 300 grams per litre.

As a general rule, low VOC paints marketed by reputable paint manufacturers usually meet the 50 g/L VOC threshold. Paints with the Green Seal Standard (GS-11) mark are certified lower than 50 g/L.

Low VOC paints will still emit an odour until dry. If you are particularly sensitive, make sure the paint you buy contains fewer than 25 grams/litre of VOC's

9.2 GENERAL

The provision of the latest revisions of the following IS: Codes shall form a part of this specification.

IS: 63	Whiting for Paints Ready mixed paint, brushing, grey filler, for Enamels, for use over primers.
IS: 426	Specification for paste filler for colour coats.
IS: 428	Specification for Distemper, Oil Emulsion, and colour as required.
IS: 710	Marine Plywood
IS: 1200 (Part XIII)	Method of Measurement of Building and Civil Engg Works - White Washing, colour washing, distempering and other finishes.
IS: 1477 (Part 1)	Code of practice for painting of ferrous metals in buildings Pre-treatment
IS: 1477 (Part 11)	Code of practice for finishing of ferrous metals in buildings. Painting
IS: 2338 (Part 1)	Code of practice for finishing of wood and wood based materials Operations and workmanship for finishing.
IS: 2338 (Part 11) :	Code of practice for finishing of wood and wood based materials, Schedule
IS: 2395 (Part 1) :	Code of practice for painting concrete masonry and plaster surfaces. Operation and workmanship
IS: 2395 (Part 11)	Code of practice for painting concrete, masonry and plaster surfaces. Schedule.

IS: 159	Specification for ready mixed paint, brushing, acid resistant.
IS: 2524 (Part 1)	Code of practice for painting of non-ferrous metal in buildings Pre-treatment
IS: 2524 (Part II)	Code of practice for painting of non-ferrous metal in buildings Painting
IS: 3140	Code of practice for painting asbestos cement buildings:
IS: 5410	Specification for cement paints, colour as required.

Other IS Codes not specifically mentioned here, but pertaining to painting form part of these specifications.

9.3 MATERIALS

Materials shall strictly conform to the relevant IS: Specifications.

9.4 PLASTERED OR CONCRETE SURFACES

Wherever scaffolding is necessary, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be painted. Properly secured and well tied suspended platforms (JHOOLA) may be used for painting. Where ladders are used, pieces of old gunny bags shall be tied at top and cotton to prevent scratches to the walls and floors. For painting of ceilings, proper stage scaffolding shall be erected, where necessary.

Please note that the figures below are a guide only, as the actual VOC rating will depend on gloss level selected. All figures exclude tinting.

-Note that the exact VOC rating will vary depending on the sheen level, so the range is given to cover all.

-All measurements are in grams per litre for untainted product

The surface shall be thoroughly cleaned off all dirt, dust, mortar dropping and other foreign matter, before paint is to be applied. New plaster surfaces shall be allowed to dry for at least 2 months, before applying paint. All unnecessary nails shall be removed. Pitting in plaster shall be made good with putty. The surface shall then be rubbed down again with a fine grade sand paper and made smooth.

The surface shall be allowed to dry thoroughly before the regular cost of paint is allowed.

The surface affected by moulds moss, fungi, algae, linens, efflorescence shall be treated in accordance with IS 2395 (Part 1) before applying paint.

9.5 OIL-BOUND DISTEMPERING

9.5.1 Materials

Oil emulsion (Oil Bound) washable distemper (IS 428) of approved brand and manufacture shall be used. The primer wherever used for new work shall be cement primer or distemper primer as described in the item. These shall be of the same manufacture as distemper. The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day's work shall be prepared. The distemper and primer shall be brought by the contractor in sealed tins in sufficient quantities at a time to suffice for a fortnight's work, and the same shall be kept in the joint custody of the contractor and the PMC/Employer. The empty tins shall not be removed from the site of work, till this item of work has been completed and passed by the PMC/Employer

9.5.2 Preparation of Surfaces

For new work the surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filling up the undulation and then sand papering the same after it is dry. In the case of old work, all loose pieces and scales shall be removed

by sand papering. The surface shall be cleaned of all grease, dirt etc. Pitting in plaster shall be made good with plaster of Paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

9.5.3 Primer Coat

The primer where used as on undercoated surfaces shall be alkali resistance primer or distemper primer as specified in the item. These shall be of the same manufacture as of oil bound distemper. If the wall surface plaster has not dried completely alkali resistance primer shall be applied before distempering the walls. But if the distempering is done after the wall surface is dried completely, distemper primer shall be applied.

9.5.4 Application

Primer shall be applied with a brush on the clean dry and smooth surface. Horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks. It shall be allowed to dry for at least 48 hours, before oil bound distemper or paint is applied.

9.5.5 Preparation of oil bound distemper

The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for days work shall be prepared.

9.5.6 Application of distemper coat

After the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the printing coat. All loose particles shall be dusted off after rubbing. Minimum two coats of distemper shall be applied with brushes in horizontal strokes followed to immediately by vertical which together shall constitute one coat. The subsequent coats shall be applied after a time interval of at least 24 hours between consecutive coats to permit the proper drying of the preceding coat.

The finished surface shall be even and uniform without patches, brush marks, distemper, drops, etc. Sufficient quantity of distemper shall be mixed to finish one room at a time. The application of a coat in each room shall be finished in one operation and no work shall be started in any room, which cannot be completed the same day.

15 cm. double bristled distemper brushes shall be used. After each day's work, brushes shall be thoroughly washed in hot water with soap solution and hung down to dry. Old brushes which are dirty and caked with distemper shall not be used on the work.

9.5.7 Scaffolding:

Wherever scaffolding is necessary, it shall be erected on double supports tied together by horizontal pieces, over which scaffolding planks shall be fixed. No ballies, bamboos or planks shall rest on or touch the surface which is being white washed. For all exposed brick work or tile work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

Note: In case of special type of brick work, scaffolding shall be got approved from PMC/Employer in advance. Wherever ladders are used, pieces of old gunny bags shall be tied on their tops to avoid damage or scratches to walls. For white washing / painting the ceiling, proper stage scaffolding shall be erected

9.5.8 Precautions/protective measures

Doors, windows, floors, articles of furniture etc. and such other parts of the building not to be white washed/ painted, shall be protected from being splashed upon. Splashing and droppings, if any shall be removed by the contractor at his own cost and the surfaces cleaned. Damages if any to furniture or fittings and fixtures shall be recoverable from the contractor

9.5.9 Measurement:

The Mode of measurement shall be as per IS 1200

9.5.10 Rate:

The rate shall include all material and labour involved in all the operations described above

9.6 WATER PROOF CEMENT PAINT

9.6.1 Materials

The cement Paint shall be (conforming to IS 5410) of approved brand and manufacture. The cement Paint shall be brought to the site of work by the contractor in its original containers is sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the Contractor and the PMC/Employer. The empty containers shall not be removed from the site of work till the relevant item of the work has been completed and permission obtained from the PMC/Employer

9.6.2 Preparation of Surfaces

For New Work, the surface shall be thoroughly cleaned of all mortar dropping, dirt dust, algae, grease and other foreign matter by brushing and washing. Pitting in plaster shall be made good and a coat of water proof cement Paint shall be applied over patches after wetting them thoroughly. The surfaces shall be thoroughly wetted with clean water before the water proof cement paint is applied.

9.6.3 Preparation of Paint

Portland cement paints are made readily by adding paint power to water and stirring to obtain a thick paste which shall then be diluted to a brush able consistency. Generally equal volumes of paint powder and water make a satisfactory paint. In all cases the manufacturer's instructions shall be followed. The paint shall be mixed in such quantities as can be used up within an hour of mixing as otherwise the mixture will set and thicken, affecting flow and finish.

The lids of cement paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement paint rapidly becomes air set due to its hygroscopic qualities.

9.6.4 Application of Paint

No painting shall be done when the paint is likely to be exposed to a temperature of below 7 degree within 48 hours after application.

When weather conditions are such as to cause the paint to dry rapidly, work shall be carried out in the shed as far as possible. This helps the proper hardening of the paint film by keeping the surface moist for a longer period.

To maintain a uniform mixture and to prevent segregation the paint shall be stirred frequently in the bucket.

For undecorated surfaces, the surface shall be treated with minimum two coats of water-proof cement paint. Not less than 24 hours shall be allowed between two coats and the second or subsequent coat shall not be started until the preceding coat has become sufficiently hard to resist marking by the brush being used. In hot dry weather the preceding coat shall be slightly moistened before applying the subsequent coat.

The finished surface shall be even and uniform in shade without patches, brush marks, paint drops, etc. Cement paints shall be applied with a brush with relatively short stiff hog or fibre bristles. The paint shall be brushed in uniform thickness and shall be free of excessively heavy brush marks. The laps shall be well brushed out. For unplastered surfaces the contractor to apply suitable putty before application of paint. This is to be included in the rate for cement paint

9.6.5 Curing

Painted surfaces shall be sprinkled with water two or three times a day. This shall be done between coats and for at least two days following the final coat. The curing shall be started as soon as the paint has hardened so as not to be damaged by the sprinkling of water say about 12 hours after its application.

9.6.6 Scaffolding

Scaffolding shall be as mentioned under the head of Oil Bound Distemper

9.6.7 Precautions/protective measures:

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.6.8 Measurement

The Mode of measurement shall be as per IS 1200

9.6.9 Rate

The rate shall include all material and labour involved in all the operations described above

9.7 PAINTING WOOD AND METAL SURFACES

9.7.1 General Requirement

The materials required for the execution of painting work shall be obtained directly from approved manufacturers and brought to the site in maker's drums, with seals unbroken. All paints shall conform to relevant Indian Standards as mentioned under sub-head "Material".

All materials not in actual use shall be kept properly protected. Lids of containers shall be kept closed and surface of paint in open or partially open containers covered with a thin layer of turpentine to prevent formation of skin. Materials which have become stale or fat due to improper and long storage shall not be used. The paint shall be stirred thoroughly in its container before pouring into small containers. While applying also, the paint shall be continuously stirred in the smaller container. No left over paint shall be put back into stock tins. When not in use, the containers shall be kept properly closed.

If for any reason thinning is necessary, in case of ready mixed paint, the brand of thinner recommended by manufacturer shall be used.

Painting except the priming coat shall generally be taken in hand after all other builder's work is practically finished. The rooms shall be thoroughly swept out and the entire building cleaned up at least one day in advance of the paint work being started. The surface to be painted shall be thoroughly cleaned and dusted. All rust, dirt scales, smoke and grease shall be thoroughly removed before painting is started.

No painting on exterior or other exposed parts of the work shall be carried out in wet, humid or otherwise unfavourable weather and all the surfaces must be thoroughly dry before painting work is started.

9.7.2 Brushing of Paint:

The brushing operations are to be adjusted to the spreading capacity advised by the manufacturers of the particular paint. The painting shall be applied evenly and smoothly by means of crossing and laying

off, the later in the direction of the grain of wood. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternatively in the opposite directions two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

During painting, every time after the paint has been worked out of the brush bristles or after the brush has been unloaded, the bristles of the brush. (Which are drawn together due to the high surface tension) shall be opened up by striking the brush against a portion of the unpainted surface with the end of the bristles held at right angles to the surface, so that bristles thereafter will collect the correct amount of paint when dipped again into the paint container.

9.7.3 Spraying

Where so stipulated, the painting shall be done with spray. Spray machine used may be (a) high pressure (small air aperture) type or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

Spraying should be done only when dry conditions prevail. During spraying the spray gun shall be held perpendicular to the surface to be coated and shall be passed over the surface in a uniform sweeping motion. Different air pressures and fan adjustment shall be tried so as to obtain the best application with the minimum wastage of paint. The air pressure shall not be kept too high as otherwise the paint will clog up and will be wasted.

Spots that are inaccessible to the spray pattern shall be touched up by brush after spraying.

At the end of the job, the spray-gun shall be cleaned thoroughly so as to be free from dirt. Incorrect adjustments shall be set right, as otherwise they will result in variable spray patterns, runs, sags and uneven coats.

Each coat shall be allowed to dry completely and lightly rubbed with very fine grade of sand paper and loose particles brushed off before next coat is applied. Each coat shall vary slightly in shade and shall be got approved from the PMC/Employer before next coat is started.

Each coat except the last coat shall be lightly rubbed down with sand paper or fine pumice stone and cleaned off dust before the next coat is applied.

No hair marks from the brush or clogging of paint puddles in the corner panels, angles of moulding, etc. shall be left on the works. In painting doors and windows, the putty round the glass panes shall also be painted but care shall be taken to see that no paint stains etc. are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting.

In painting steel work, special care shall be taken while painting over bolts, nuts, rivets, overlaps etc.

The additional specifications for primer and other coats of paints shall be according to the detailed specifications under the respective headings.

9.7.4 Brushes and containers:

After work, the brushes shall be completely cleaned off paint and linseed oil by rinsing with turpentine. After cleaning, the brushes are wrapped in heavy paper or water proof paper for storage. It is to be used the next day; it shall be hung in a thinner or linseed oil in a container. On no account shall brushes to be made to stand on bristles. A brush in which paint has dried up is ruined and shall on no account be used for painting work.. The containers, when not in use, shall be kept closed and free from air so that paint does not thicken and also shall be kept guarded from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, before they can be used again.

9.7.5 Scaffolding:

Scaffolding shall be as mentioned under the head of Oil Bound Distemper

9.7.6 Precautions/protective measures

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.7.7 Measurement

The Mode of measurement shall be as per IS 1200

9.7.8 Rate

The rate shall include all material and labour involved in all the operations described above

9.8 PAINTING TO STEEL AND OTHER METAL SURFACES**9.8.1 Preparation of Surfaces**

The surface before painting shall be cleaned of all rust, scale, dirt and other foreign matter sticking to it with wire brushes, steel wool, scrappers, sand papers etc. The surfaces shall then be wiped finely with mineral turpentine which shall also remove grease and perspiration of hand marks. The surface shall then be allowed to dry.

9.8.2 Application of primers and paints

After preparation of the surface, the priming coat shall be applied immediately. The specifications for application shall conform to Para on painting wood surfaces above.

9.8.3 Scaffolding

Scaffolding shall be as mentioned under the head of Oil Bound Distemper

9.8.4 Precautions/protective measures

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.8.5 Measurement

The Mode of measurement shall be as per IS 1200

9.8.6 Rate

The rate shall include all material and labour involved in all the operations described above

9.9 PAINTING TO WOOD AND WOOD BASED MATERIALS:**9.9.1 Preparation of Surface**

All wood work shall be dry and free from any foreign matter, incidental to building operation. Nails shall be punched well below the surface to provide a firm key for stopping. Moulding shall be carefully smoothened with abrasive paper and projecting fibres shall be removed. Flat portions shall be smoothened off with abrasive paper used across the grain prior to painting. Any knots, resinous, streaks or bluish sap wood that are large not enough to justify cutting out shall be treated with two coats of pure shellac knotting, applied thinly and extended about 25 mm beyond the actual area requiring treatment.

9.9.2 Plywood and Block Board

This shall be treated as for solid wood, described above.

9.9.3 Hard Boards

The surface shall be dusted off and painted with a coat of plastic emulsion paint thinner with water or with a coat of shellac varnish as specified. The surface shall then be rubbed down with fine grade abrasive paper and followed with required under coating and finishing coat as for soiled wood.

9.9.4 Particle Board

The surface shall be filled with thin brush able filler and finished as for solid wood.

9.9.5 Insulation Boards

Two thin coats of water based paints shall be applied by spraying.

9.9.6 Priming Coat

The dirt or any other extraneous material shall be removed from the surface to be painted. In case the surface is already finished with primer coat but unsatisfactory, it shall be rubbed down to bare wood and surface re-primed. Primer shall be applied by brushing.

9.9.7 Application for transparent wood filler

The filler shall be applied with brush or rag in such a way that it fills up all the pores and indentations and levels up the surface. It shall be allowed to dry for 24 hours and it shall then be cut and rubbed with emery paper so that the surface of the wood is laid bare, with, the filler only in the pores and crevices of the wood.

9.9.8 Stopping

All holes, cracks, crevices, etc. shall be stopped carefully to true and level surface with putty before the main undercoat is applied and after the application of the priming coat, stopping shall be prepared as below:

Bees wax, resin and lac (orange in colour) in the proportion of 1: 1: 16 by weight shall be melted down together in a suitable pot using slow heat, the mix being kept well stirred. Colouring materials to produce the required shade shall be added into molten mixture and stirred. Stopping shall on cooling be rolled into stick forms for use.

9.9.9 Application of Paints

The specifications for application shall conform to Para on painting wood surfaces above

9.9.10 Applying wood preservatives

The preservatives of specified quality shall be applied in two coats. On new wood work, it shall be applied liberally with a stout brush and not doubled with rags or cotton waste, the first coat shall be allowed at least 24 hours to soak in before the second coat is applied. The excess of preservative which does not soak into the wood shall be wiped off with a clean dry piece of cloth.

9.9.11 Scaffolding

Scaffolding shall be as mentioned under the head of Oil Bound Distemper

9.9.12 Precautions/protective measures:

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.9.13 Measurement:

The Mode of measurement shall be as per IS 1200

9.9.14 Rate

The rate shall include all material and labour involved in all the operations described above

9.10 WHITE WASHING**9.10.1 General**

The item refers to white-washing over old and new concrete, stone masonry brick plastered surfaces and asbestos cement sheets.

White wash shall be prepared from fresh burnt white stone lime or shell lime. This lime shall be of class C type as per IS: 712. Surkhi lime or lime of equivalent quality may be used. The lime shall be dissolved in a tub with sufficient quality of water (about 4.5 litres/Kg. of lime) and the whole shall be thoroughly mixed and stirred until it attains the consistency of thin cream. The white wash shall be taken out in small quantities and strained through a clear course cloth. Alternatively, with IS: 63 may also be used. Clean gum dissolved in hot water shall then be added in suitable proportion of 2 gm of gum Arabic to a litre of lime or whiting to prevent the white- wash coming off easily when rubbed. Rice may be used instead of gum.

9.10.2 Scaffolding

This may be double or single according to requirements. If ladders are used, pieces of old gunny bags or cloth rags shall be tied on their tops to avoid damage or scratches to the wall. Proper stage scaffolding shall be created when white-washing ceiling. The contractor shall be responsible for accidents if any taken place.

9.10.3 Preparation of Surface

The surface shall be prepared by removing all mortar dropping and foreign matter and thoroughly cleaned with wire or fibre brush or other means as may be ordered by the PMC/Employer to produce an approved clean and even surface. All loose pieces and the scales shall be scraped off and holes stopped with mortar. In case where the surface has been previously coloured-washed, the old colour wash must be entirely removed before the white-wash is applied. In the case of surface which has once been white-washed, the old loose white-wash shall be broomed down. In case, the loose white-wash cannot be removed by brooming, the PMC/Employer may order scraping of the surface.

After cleaning the surface as specified above, the unwanted nails shall be removed and all nail holes, cracks and crevices stopped with mortar similar in composition to the surface to be stopped. The mortar should be cured.

9.10.4 Application of white-wash

On the surface so prepared, the white-wash shall be laid. Each coat shall be laid on with a brush. The first stroke of the brush shall be from the top downwards, another from bottom upwards over the first stroke, and similarly, one stroke from the right and another from the left over the first brush before it dries. This will form one coat. Each coat must be allowed to dry and shall be subject to inspection before

the next coat is applied. When dry, the surface shall show no signs of cracking. It shall present a smooth and uniform finish free from brush marks and it should not come off easily when rubbed with a finger. No portion in the surface shall be left out initially, to be patched up later on.

For new work, the white washed surface shall present a smooth and uniform finish.

For old work, patches and repairs shall be white washed first. Thereafter, the whole surface shall be white washed with the required number of coats.

Doors, windows, floors and other articles of furniture, etc., shall be protected from being splashed upon. Splashing and droppings, if any, shall be removed and the surfaces cleaned.

Preparing the surface for white wash including the scaffolding

Applying the white wash in required number of coats as specified above and prior white washing of repaired patched.

9.10.5 Precautions/protective measures

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.10.6 Measurement

The Mode of measurement shall be as per IS 1200

9.10.7 Rate

The rate shall include all material and labour involved in all the operations described above

9.11 PLASTIC EMULSION PAINTING ON WALL AND CEILING

9.11.1 General

Plastic emulsion paints are not suitable for application on external wood and iron surfaces and surfaces which are liable to heavy condensation and are to be used generally on masonry or plastered surfaces. Suitable primer as per manufacturer shall be provided.

9.11.2 Paint

Plastic emulsion paint of approved brand and manufacture and of the required shade shall be used.

9.11.3 Preparation of Surface

The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filling up the undulation and then sand papering the same after it is dry.

9.11.4 Application

The number of coats shall be as stipulated in the item. The paint will be applied in the usual manner with brush or roller. The paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surfaces to 2 to 3 hours on non-absorbent surfaces.

The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the undercoat which is applied on the absorbent surface. The quantity of thinner to be added shall be as per manufacturer's instructions. The surface on finishing shall present a flat velvety smooth finish. If necessary, more coats will be applied till the surface presents a uniform appearance.

9.11.5 Precautions

Old brushes if they are to be used with emulsion paints, should be completely dried of turpentine or oil paints by washing in warm soap water. Brushes should be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the paint from hardening on the brush.

In the preparation of walls for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.

Splashes on floors etc. shall be cleaned out without delay as they will be difficult to remove after hardening.

Washing of surfaces treated with emulsion paints shall not be done within 3 to 4 weeks of application.

9.11.6 Other Detail

These shall be as per specification for "Painting" as far as they are applicable.

9.12 ACRYLIC PAINTING TO EXTERNAL SURFACES:

Acrylic weather shield paint of approved brand shall be applied over plastered surfaces as directed by the PMC.

Other specifications including preparation of surfaces, application of paint etc. shall conform to paint above and as directed by PMC. The priming coat, anti-fungal treatment, preparation of paint etc. shall be carried out as per manufacturer's specification / as directed by PMC.

9.13 EXTERNAL TEXTURE PAINTING

Painting work to be carried out by authorized applicator only as recommended by approved paint manufactures,

Method Statement to be submitted for approvals by the contractors as submitted by the authorized applicator.

9.13.1 Sealer Coat

Allow new surface to dry out completely. It is recommended to allow at least 12 weeks as the curing time for new masonry surfaces. Please ensure pH level between 7 & 9 before painting. Ensure that the surface is clean and free from grime, dust, flakes, grease etc. For old surfaces, remove all loosely adhering particles, powdery materials or defective paints by thorough brushing, scraping and water jetting, if required. For algae & fungus-affected area, application of Pre Treatment Coat is recommended. Note: It is recommended not to apply any kind of putty. Do not apply Exterior Sealer during wet weather. On horizontal surfaces, it is recommended to do 3 coats of topcoat material. For best results and for surfaces that remain powdery, friable or chalky even after thorough preparation, application of topcoat material as primer with 1:1 dilution in water as an extra coat, is recommended. Fill up all minor cracks and defects with cement and sand mixture in the ratio 1:3. Avoid application of putty or filling compound. Exterior Sealer should not be applied to the surfaces or substrates which are exposed to continuous seepage or dampness. For best adhesion performance, the moisture content in the wall should not exceed 10%.

Dilute 1 part of Exterior Sealer with 1 part of clean water by volume.

Note: Excessive dilution from that recommended will result in low coverage and may impact application properties and color.

9.13.2 Application Tools: By roller, brush or conventional /airless spray (nozzle size 0.5mm to 0.7mm)

9.13.3 Texture Application

9.13.3.1 Surface preparation

Ensure surface is thoroughly clean, dry and free from all loose dirt, chalk, grease, fungi, algae and flaking paint. This can be achieved by brushing with a wire/stiff coir brush followed by water jetting if required. Fill up all minor cracks and defects with cement and sand mixture in the ratio 1:3. Avoid application of putty or filling compounds while painting an exterior surface. Application of one coat of Pre-Treatment coat is recommended for better performance of the paint.

9.13.3.2 Application Tools: By roller, brush or conventional /airless spray (0.5mm to 3mm) / trowel (hand or machine as per paint supplier recommendation) in one or two coats as per the approved pattern of texture selected.

9.13.3.3 Dilution

No thinning of the material is recommended for the final coat. But for ease of application a little water can be sprinkled.

9.13.4 Final Coat of Paint

As mentioned in Acrylic Emulsion Exterior Grade Paint

9.14 Quality Control for all Types of Paint

Only the paints which have been tested for the following qualities as per the specification given in the relevant IS codes should be used:

- drying time
- flexibility and adhesion
- consistency
- dry thickness and rate of consumption

Unless otherwise specified all painting and protective coating work shall be done in accordance with IS: 1477.

Test certificates shall be furnished by the CONTRACTOR for PMC/Employer approval and acceptance.

9.15 CONSUMPTION OF PAINT FOR DIFFERENT PAINTING ITEMS

Sl no.	Brief description of painting work	Consumption per 10 Sqm. Of net
A	Oil bound distemper on plastered surfaces:	
1	Cement primer (one coat)	0.91 litres
2	Two finishing coats	1.60 kg
3	Three finishing coats	2.4 kg
B	Flat oil paint to plastered surfaces:	
1	Cement primer (one coat)	0.91 litres
2	Cement primer (two coats)	1.82 litres
3	Two finish coats	1.72 litres

Sl no.	Brief description of painting work	Consumption per 10 Sqm. Of net
C	Acrylic emulsion paint:	
1	Cement primer (one coat)	0.91 litres
2	Two finishing coats (two coats)	0.87 litres
3	Three finish coats	1.30 litres
D	Cement paint (old surface):	
1	Two coats on sand faced plastered surface	4.10 kg
2	Two coats on rough cast plastered surface	7.70 kg
E	Cement paint (old surface):	
1	Two coats on sand faced plastered surface	4.50 kg
2	Two coats on rough cast plastered surface	8.50 kg
F	Enamel paint to wood / steel:	
1	Wood primer (one coat)	0.90 litres
2	Steel primer (one coat)	0.75 litres
3	Two finishing coats on wood	1.40 litres
4	Two finishing coats on steel	1.35 litres
G	Flat oil paint to wood /steel work:	
1	Wood primer (one coat)	0.90 litres
2	Steel primer (one coat)	0.75 litres
3	Two finishing coats on wood	1.70 litres
4	Two finishing coats on steel	1.70 litres
H	External painting with flat oil paint:	
1	Cement primer (one coat)	1.00 litres
2	Two finishing coats	1.74 litres
I	Re-painting old painted surfaces:	
1	Two coats of emulsion paint	0.86 litres
2	Two coats of flat oil paint	1.59 litres
3	Two coats of enamel paint	1.35 litres

(The consumption give is indicative only. Please check the respective vendors for more details and accurate figure. No escalation will be paid on account of increase in the consumption of paint)

9.16 MEASUREMENT

Painting on plastered or concrete surface shall be measured as for plastering. Painting on wooden or metal surfaces shall not be measured separately and is deemed to be included in the respective item for wood and MS respectively.

IS 1200 shall be followed for measuring all painting

10 FLOOR FINISHES**10.1 SCOPE**

These Specifications covers flooring, skirting, dado or cladding works using different types of stone/ slabs/ tiles as detailed hereunder:

10.2 GENERAL

The provision of the latest revisions of the following IS Codes shall form a part of this specification to the extent they are relevant:

IS: 269	Specification for ordinary, rapid hardening and low heat Portland cement.
IS: 383	Specification for coarse and fine aggregate from natural sources for concrete
IS: 777	Specification for glazed earthenware tiles.
IS: 1200 Part XI	Method of measurements for Building and Civil Engg. Works, paving, floor finishes, dado and skirting.
IS: 1237	Specification for cement concrete flooring tiles.
IS: 1443	Code of practice for laying and finishing of cement concrete flooring tiles.
IS: 2541	Code of practice for use of lime concrete in buildings.
IS: 2571	Code of practice for laying in situ cement concrete flooring
IS: 10067	Material Constants in Building Work

Other I.S Codes not specifically mentioned here, but pertaining to Floor Finishes form part of these specifications. NBC 2005, 2016 Vol-I & Vol II for Fire Safety & mandate requirements for Differently abled individuals.

10.3 INDIAN PATENT STONE FLOORING**10.3.1 MATERIALS****10.3.1.1 Cement concrete**

The cement concrete shall generally conform to specifications for ordinary concrete. The coarse aggregates shall be carefully selected, sufficiently tough and hard stone pieces broken in a manner that will provide particles of approximately cubical shape affording good interlocking. The fine aggregate shall consist of properly graded particles. The proportion of mix shall be M15 or as mentioned in the BOQ. The least amount of mixing water that will produce a workable mix and will allow finishing without excessive travelling shall be used.

10.3.1.2 Workmanship

The sub-grade in all cases shall be formed to proper levels and slopes, well compacted and cured. The top surface shall be kept slightly rough.

The surface of the sub-grade shall be cleaned off all loose materials and moistened immediately before laying the concrete floor. The concrete flooring shall be laid in alternate bays not exceeding 6.25 Sqm (about 64 sf.ft) each. The edge of each panel into which the floor is divided should be supported by flat bars of steel or wood duly oiled to prevent sticking. Their depth shall be the same as that proposed for the finished floor as mentioned in the item. The bars should be removed before filling in the adjoining panels. At least 48 hours shall elapse before the concreting in the adjacent bays is commenced.

The concrete shall be laid immediately after mixing. While being placed the concrete shall be vigorously sliced and spaded with suitable tools to prevent formation of voids or honey comb pockets. The concrete shall be brought to the specified levels by means of a heavy straight edge resting on the side forms and drawn ahead with a sawing motion in combination with a series of lifts and drops alternating with small lateral shifts. While concreting the adjacent bays care shall be taken to ensure that the edges of previously laid bays are not broken by careless or hard tamping.

Immediately after laying the concrete, the surface shall be inspected for high or low spots and any needed correction made up by adding or removing the concrete. After striking off the surfaces to the required grade concrete shall be compacted with a wooden float. The blows shall be fairly heavy in the beginning but as consolidation takes place, light rapid strokes shall be given to complete the ramming. The floating shall be followed by steel travelling after the concrete has hardened sufficiently to prevent excess of fine material from working to the surface. The finish shall be brought to a smooth and even surface free from defects and blemishes and tested with straight edges. No dry cement or mixture of dry cement and sand shall be sprinkled directly on the surface of the concrete to absorb moisture or to stiffen the mix. After the concrete has been thoroughly rammed and has dried sufficiently to allow rendering to be worked up, surface shall be rendered with a thin coat of 1:1 cement mortar with fine sand and uniformly floated. If so directed by the PMC/Employer approved mineral colour pigment conforming to appendix-B of IS 657 shall be added to the cement mortar to give the required colour and shade to the flooring. When the cement mortar rendering is sufficiently stiff, lines shall be marked on it with strings or by any other device to give the appearance of tiles 30 x 30 cm or of any other size laid diagonally or square as directed by the PMC/Employer. The junctions of floor and walls shall be rounded off if so directed, without any extra payment.

After the concrete in the bays has set, the joints of the panels shall be filled with cement cream or with suitable bitumastic compound as shown on the drawings or directed by the PMC/Employer. Vertical edge of the bays shall be neatly marked on the surface of the concrete with a pointed trowel after filling the joints.

10.3.1.3 Finishing:

When the rendering is somewhat stiff, neat cement may be sprinkled on sparingly through a paper pot on the surface and rubbed lightly to give smooth polished ordinary cement coloured surface. If coloured flooring is required by the PMC/Employer the approved coloured cement shall be used. Surface shall be protected after completion of work till handover.

10.3.1.4 Curing:

Curing shall start on the next day after finishing and shall be continued for 14 days.

10.3.2 MODE OF MEASUREMENT

Mode of measurement shall be plan Area in Sqm.

10.4 IPS WITH NON METAL HARDNERS

Cement concrete flooring of specified thickness and mix as per 'Itemized Schedule of Quantities' shall be laid as specified under the specification of cement concrete flooring. The top surface shall be roughened with brushes while the concrete is still green and the forms shall be kept projecting up 12mm. Over the concrete surface to receive the metallic hardening compound topping.

The non metal hardeners shall be as per the manufacturer's specifications. All installation procedure, mixing, laying procedure shall be as per manufacturer's specifications.

10.4.1 MODE OF MEASUREMENT

Mode of measurement shall be plan Area in Sqm.

10.5 KOTA FLOORING

10.5.1 KOTA STONE SLABS

The slabs shall be of selected quality, hard, sound, dense and homogeneous in texture free from cracks, decay, weathering and flaws. They shall be hand or machine cut to the requisite thickness. They shall be of the colour indicated in the drawings or as instructed by the PMC/Employer.

The slabs shall have the top (exposed) face polished before being brought to site, unless otherwise specified. The slabs shall conform to the size required. Before starting the work the contractor shall get the samples of slabs approved by the PMC/Employer.

10.5.2 DRESSING

Every slab shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth so that a straight edge laid along the side of the stone shall be in full contact with it. The sides (edges) shall be table rubbed with coarse sand or machine rubbed before paving. All angles and edges of the slabs shall be true, square and free from chippings and the surface shall be true and plane.

The thickness of the slab after it is dressed shall be 20, 25, 30 or 40 mm as specified in the description of the item. Tolerance of ± 2 mm shall be allowed for the thickness. In respect of length and breadth of slabs Tolerance of ± 5 mm for hand cut slabs and ± 2 mm for machine cut slabs shall be allowed.

10.5.3 PREPARATION OF SURFACE AND LAYING

Base concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 (1 cement: 4 coarse sand) or as given in the description of the item.

The average thickness of the bedding mortar under the slab shall be 25 mm and the thickness at any place under the slab shall be not less than 12 mm.

The slabs shall be laid in the following manner:

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness specified in the item. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4.4 kg of cement per Sqm. The edges of the slab already paved shall be buttered with grey cement with or without admixture of pigment to match the shade of the Kota slabs as given in the description of the item.

The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine a joint as possible. Subsequent slabs shall be laid in the same manner. After each slab has been laid, surplus cement on the surface of the slabs shall be cleaned off. The flooring shall be cured for a minimum period of seven days. The surface of the flooring as laid shall be true to levels, and, slopes as instructed by the PMC/Employer. Joint thickness shall not be more than 1 mm.

10.5.4 POLISHING AND FINISHING

The day after the tiles are laid all joints shall be cleaned of the grey cement grout with a wire brush or trowel to a depth of 5 mm and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shape of the topping of the wearing layer of the tiles. The same cement slurry shall be applied to the entire surface of the tiles in a thin coat with a view to protect the surface from abrasive damage and fill the pin holes that may exist on the surface.

The floor shall then be kept wet for a minimum period of 7 days. The surface shall thereafter be grounded evenly with machine fitted with coarse grade grit block (No. 60). Water shall be used profusely during grinding. After grinding the surface shall be thoroughly washed to remove all grinding mud,

cleaned and mopped. It shall then be covered with a thin coat of grey or white cement, mixed with or without pigment to match the colour of the topping of the wearing surface in order to fill any pin hole that appear. The surface shall be again cured. The second grinding shall then be carried out with machine fitted with fine grade grit block (No. 120).

The final grinding with machine fitted with the finest grade grit blocks (No. 320) shall be carried out the day after the second grinding described in the preceding Para or before handing over the floor, as ordered by the PMC/Employer.

For small areas or where circumstances so require, hand grinding/polishing with hand grinder may be permitted in lieu of machine polishing after laying. For hand polishing the following carborundum stones, shall be used:

1st grinding — coarse grade stone (No. 60)

Second grinding — medium grade (No. 80)

Final grinding — fine grade (No. 120)

In all other respects, the process shall be similar as for machine polishing.

After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gm per square metre sprinkled with water and rubbed hard with a 'namdah' block (pad of woollen rags). The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with a wooden mallet.

10.6 EPOXY COATING

Epoxy coating should be based on carefully selected solvent less Epoxy resin composition. It should be a 3 component system consisting of base, hardener and hard wearing quartz fillers. It should be self levelling composition and forms a very smooth, attractive hygienic, hard wearing and chemical resistant floor topping.

It should provides a joint less flooring making it dust free and is easy to clean because of smooth surface.

Chemical Resistant – It should have excellent chemical resistance to most chemicals

Wear Resistant – It should provide a tough floor topping to withstand foot and light vehicular traffic.

10.6.1 SURFACE PREPARATION

The long term durability of the applied Epoxy topping is dependent upon the adhesive bond achieved between the flooring material and substrate. It is most important therefore, that substrate surface is correctly prepared prior to application.

Substrate must be of sufficient strength to support loads applied through the topping. New concrete or Cementitious substrates should have been placed for at least 28 days and have a moisture content of less than 5% before topping. Before application, the surface to be coated should be free from loose particles, rust, oils,

grease or earlier coatings and should be thoroughly dry. After surface is dry, all repair work like sealing of joints, cracks filling of cavities and crevices should be carried out. 5. The self levelling action is very localised and does not eradicate irregularities of level present in the original substrate. It is most important, therefore, that adequate surface preparation and repair is undertaken prior to application of flooring systems.

10.6.2 PRIMING

This is to be as per manufacturer's specifications.

10.6.3 MIXING

This is to be as per manufacturer's specifications.

10.6.4 LAYING

Spread the mixture on the floor immediately to the required thickness by means of rollers and serrated trowels. The floor should be rolled by a spike roller to remove trapped air. The floor shall self level to uniform colour and smoothness.

10.7 CERAMIC TILES /VITRIFIED TILES FLOOR AND DADO

10.7.1 Ceramic tiles shall be 300mm x 300mm x 7mm thick in size or as mentioned in the BOQ, Vitrified tiles to be 600x600x10mm thick/900 x 900 x 12mm / 1000 x 1000 x 12mm or as specified in the Item and of best quality, Indian make obtained from approved manufacturer. The tiles shall be sound, hard, well and evenly treated, free from twist, with fine and sharp edges. Sample of the tiles shall be first got approved by the PMC/Employer in case of the Contractor's supply and all the tiles which shall be used in the work shall strictly conform to the approved sample otherwise all the tiles will be rejected. The surface to be laid for the flooring or dado shall be thoroughly hacked, joints of masonry racked, cleaned of all mortar scales, concrete lumps, loose materials, etc. and washed to remove mud, dirt, etc. from the surface. Unless and until the surface is approved by the PMC/Employer, the flooring and dado shall not be started. The prepared surface shall be thoroughly drenched with water.

10.7.2 Flooring

A bedding 20 mm thick (unless otherwise specified) of cement mortar 1:3 shall be laid evenly to levels or slope as directed, The tiles shall then be laid on the bedding with a backing of thin cement paste. All tiles shall be truly and evenly set and pressed in position to obtain a uniform plane surface. The tiles shall be closed jointed and all joints shall be uniform and run in perfect straight lines. Joints shall be filled with matching cement paste. Entire finished surface shall be thoroughly cleaned to remove all cement stains, etc. The joints shall be kept wet for 7 days. Epoxy joints can also be used as a substitute for cement paste.

When tile flooring is to be laid over the existing flooring without dismantling old flooring it can be laid with adhesive. The old flooring shall be thoroughly cleaned and checked for undulations, if any shall be rectified with cement mortar 1:3 (1 cement: 3 coarse sand). Old cement concrete surface shall be hacked and cleaned off to have proper bond with the old surface. High polymer modified quick set tile adhesive (conforming to IS 15477) shall be thoroughly mixed with water and a paste of zero slump shall be prepared so that it can be used within 1.5 to 2 hours. It shall be spread over an area not more than one Sqm at one time. Average thickness of adhesive shall be 3 mm The adhesive so spread shall be combed using suitable trowel. Tiles shall be pressed firmly in to the position with slight twisting action checking it simultaneously to ensure good contact gently being tapped with wooden mallet till it is properly backed with adjoining tiles. The tiles shall be fixed within 20 minutes of application of adhesive. The surplus adhesive from the joints, surface of the tiles shall be immediately cleaned. The surface of the flooring shall be frequently checked during laying with straight edge of above 2m long so as to attain a true surface with required slope. Where spacer lugs tiles are provided these shall be filled with grout with lugs remaining exposed. Where full size tile cannot be fixed these shall be cut (sawn) to the required size and edges rubbed smooth to ensure straight and true joints. Tiles which are fixed in floor adjoining to wall shall enter not less than 10 mm under plaster, skirting or dado.

10.7.3 Dado

The prepared surface shall be plastered with cement mortar 1:3 to get a bedding of 12mm thick. The plastered surface shall be even, uniform and true to plumb. The tiles shall be fixed in position with a backing of cement paste or water proof adhesive of approved manufacturer as specified in the item. All tiles shall be evenly set and pressed in position to a true plane surface. The specifications for workmanship shall be exactly similar to tile flooring. The joints shall be filled with matching cement paste or with joint filler material of approved manufacturer as specified in the item. If the tile manufacturer specifies the use of adhesives for dado, the Contractor to use the same at no extra cost to the Client

10.8 TWIN GRANITE/MARBLE STONE FRAMES

10.8.1 Bedding shall be of grey cement-paste with minimum cement consumption of 0.21 bags per Sqm. Of applied area, unless specified otherwise in the BOQ/drawings. The base of cement shall be compacted to a reasonably true plain surface and to the required and level. The amount of water added shall be the minimum necessary to give just sufficient plasticity for laying and satisfactory bedding. Before spreading paste, the sub- base shall be cleaned off all dirt, scum or laitance and of loose material and then well wetted without forming any pools of water on the surface. The paste shall then be evenly and smoothly spread over so much area as will be covered with slabs within half an hour. The thickness of the paste shall not be less than 6 mm and not more than 12 mm.

The joints shall be cleaned and properly grouted with a neat paste of white cement with minimum cement consumption of 0.55 kg per Sqm

The proportion of mortar bedding shall be 1:4 , unless and otherwise prescribed any other proportion and shall be as per IS 2116-1965 , as applicable to non-reinforced masonry work.

The adhesion of two slab frames overlay shall be ensured with araldite or approved Ardex endure / Latecrete adhesive.

10.8.2 Laying

Laying of marble /granite stone slab frame shall be as follows :-

Before laying, the stone slab shall be thoroughly wetted with clean water. 20mm thick marble slab / tiles shall be fixed with polymer modified cement adhesive or cement paste (as per BOQ) Each stone slab then shall be gently tapped with a wooden mallet till it is firmly and properly bedded. If there is a hollow sound on gentle tapping of the slabs such slabs shall be removed and reset properly. The joints shall be as thin as possible and limited to 2mm at the maximum. Unless and until detailed in the BOQ or Drg, exposed edges of window sills/door frames, the edges shall be neatly rounded off.

Laying shall start after due consideration is given to following points and approved by the PMC/Employer.

The vertical surface for frame cladding work should be rough, fairly in plumb and in right angles with each other, Concealed plumbing and electric conducting shall be complete before the execution of frame cladding work.

Check all the right angles of the corners of bath/W.C. /toilet or pantry area. Please ensure that the plaster is in plumb.

Check the level of the wooden Patti with spirit level before commencing the cladding work.

After the frames are laid, surplus cement slurry from the joints shall be cleaned. The following day the joints shall again be cleaned, washed and wire brushed.

In case not specified in the Drawing or BOQ, and if the projection is not recommended, 6mm groove to be provided at the junction of the wall and stone frame.

Polishing and grinding shall be completed on the surfaces and edges before the laying of the stone frames. At first the grinding shall be with rough stone of grade 48 to 60. All chips shall be visible and grinding shall be uniform. It shall be cleaned with water. All pin-holes and opened out joints shall be grouted with matching coloured cement grouts supplied by the tile manufacturer. It shall be cured for a period of 7 days by keeping it moist.

Second coat cutting/grinding shall be done with carborandum stone of grade 120. The same procedure as for the first coat shall be repeated till curing is completed.

The final cutting/grinding shall be with a fine stone of 220-320 grade and shall be done with ample water.

Oxalic acid powder shall be spread 33 gm/Sqm. and polished by machine fitted with Hessian bobs. The floor shall then be washed, cleaned and dried with a soft cloth or linen. They should be hand polished by using rubbing stone.

In case of wax polishing, wax polish shall be applied to the surface. It shall be rubbed with machine. Then clean saw-dust shall be spread over the slab and rubbed with polishing machine. This will remove wax, leaving a glossy surface underneath.

10.8.3 Rates:

Apart from other factors mentioned elsewhere in this contract, the rate shall include for the following:

- 10.8.3.1 All labour, materials(except for Client supplied ones), equipments, cleaning of the sub-base, laying mortar bed and adhesives, grout, fixing marble slabs as specified above and making up the joints.
- 10.8.3.2 Transportation of material / equipment
- 10.8.3.3 Any cutting and wasting if required
- 10.8.3.4 Mouldings and edge polishing
- 10.8.3.5 All adhesives, grouts and mastic sealants etc.
- 10.8.3.6 Curing
- 10.8.3.7 Cleaning the floor and surrounding areas all stains, etc.

10.9 PANTRY / HAND WASH COUNTER

Necessary chases to be made in the wall for supporting the backing materials

Machine cut Cudappa stone slabs used shall be of 25 mm thickness, colour shall be uniform and the slabs free from all defects. Or 19mm marine ply wood to be used instead of Cudappa (as specified in the BOQ)

Slabs shall be either machine cut at factory in required sizes or cut by machine at site. In all cases no damaged stone shall be used in the work.

Vertical stones and stones of shelf shall be machine polished on both sides while the top slab shall be polished on one side i.e. underside, while top surface shall be kept rough for better adhesion with granite top.

All edges shall be sharp, perfectly rectangular and the exposed edges shall be pencil rounded and machine polished.

Assembly of toilet counter shall be done as per detail given by Architect or Engineer complete to all details and dimensions.

Vertical pieces shall be in perfect plumb on all sides while horizontal slab shall be in perfect level.

All joints and in fill layer shall be filled with cement sand mortar of mix 1:4 (1 cement : 4 sand) and properly cured.

Granite top used shall be of approved quality and shade. Thickness shall be about 20 mm and all slabs shall be machine cut.

All slabs preferable shall be from same mines and granite blocks / rocks to ensure uniformity of colour and quality.

Cutting and polishing shall be by machine only at factory. No damaged piece shall be used.

All edges shall be sharp, perfectly rectangular and the exposed edges shall be pencil rounded and polished.

Granite top shall be laid over cement mortar bed of about 20 mm thickness of mix cement mortar 1:4 (1 cement : 4 sand). Prior to laying of mortar bed the top of Cudappa stone base shall be scrapped clean and washed thoroughly. In case Granite is to be laid on ply backing, the same to be done by means of approved Adhesive from Roff or Ardex Endura or Latecrete as per the manufacturer's specifications

Mortar bed shall be laid and neat cement slurry with cement paste shall be spread over the mortar bed and clear granite slab shall be laid and fixed to perfect level over it.

Joints shall be as thin as possible and limited to 1-2 mm maximum. The joints shall be wiped off for excess cement slurry and cleaned prior to grouting with matching coloured cement grout.

Granite facia Patti shall be fixed by using anchor fasteners and epoxy based adhesives of approved type by the Engineer.

Work shall be protected and cured for at least 7 days. The timber props on braces shall be left in place as per instruction / recommendations of adhesive manufacturer.

The sink / wash basin of specified size and make shall be fixed by cutting of Cudappa stone base and the joints on top with granite shall be filled with silicon sealant of approved make and colour.

Measurements shall be in running meters or as mentioned in BOQ.

Rate shall include all materials, wastage, labour, grout, sealant, adhesives, anchors, protection, curing etc. complete. Sink/ wash basin shall be paid separately

The cost to include storage below the counter if mentioned in the BOQ

11 FALSE CEILING**11.1 MR GRADE GYPSUM BOARDS**

MR grade plaster board should be of thickness as specified in the BOQ. This is the moisture resistant gypsum plasterboard with water repellent additives in the core and paper liners. It should be suitable for Interior applications and should follow the standards and specifications as mentioned in IS 2095, Part 1. The Thermal Conductivity of the plaster board should be 0.16 (W/m²K). The longitudinal edge of the Gyp board shall be of tapered / square edges, so as to have flush joints while fixing. Handling and transporting of Gyp board shall be done carefully and as recommended by the manufacturers. The board should always be kept in a dry and covered place sheltered from rain and to avoid dampness from flow, they should be supported on wooden battens which should not be more than 45cm apart on a flat surface. The material shall be stacked in piles of smaller heights and should not be stacked on edges. Gyp board which have deformed due to poor stacking should not be used. Cutting of board should be made in faced side of the board by means of retractable knife or by using a normal saw and the edges of the boards shall be planned using proper files.

- 11.1.1 GI frame works:- The system consists of G.I. frame work suspended from the soffit of the RCC ceiling. The following G.I. components shall be used for grid work.
- 11.1.2 Ceiling section which is the main supporting section to fix plasterboard 80 x 26 x 51 x 3660mm having ribbed surfaces
- 11.1.3 Perimeter Channel used to Fix around walls / partitions having Dimensions in (mm) as 20 x 28 x 30 x 3660mm
- 11.1.4 Intermediate Channel which is used to Primary section to support the ceiling section having Dimensions in (mm) as 15 x 45 x 15 x 3660
- 11.1.5 Ceiling Angle used to provide suspensions from the structural soffit having Dimensions in (mm) as 25 x 10 x 3660mm
- 11.1.6 Connecting clips of 2.64 mm dia.
- 11.1.7 Soffit cleat 22X37mm
- 11.1.8 Anchor fasteners 6 mm

All the G.I. components shall be of approved make. The G.I. grid work system shall be suspended from the soffit of RCC ceiling using anchor fasteners of 6mm of approved type and make and connected to soffit cleats and ceiling angle by means of necessary nuts, bolts and washers etc.

11.2 METHODOLOGY

- 11.2.1 Providing and fixing suspended G.I. frame work
- 11.2.2 Providing and fixing one layer of 12.5 mm Gypboard over this frame work.
- 11.2.3 Jointing the board flush, applying two coats of primer suitable for Gypboard
- 11.2.4 Making necessary cut out for light fitting, A.C. grills diffusers and other necessities. The work shall include horizontal, vertical and inclined surfaces depending upon the various requirements.
- 11.2.5 Gypsum Board of plain or MR series 12.5 mm manufactured by Saint Gobain India Gyproc or equivalent from the approved makes list shall be used. The Gyp board shall conform to IS 2095. Gypsum boards shall be of specified thickness and of specified finish shall be screw fixed to the under side of false ceiling grid system with 12.5 mm dia dry wall screw @ 230 mm C/C by drilling machine. Joints in the board shall be finished flush with fillers, finisher and primer as per manufactures recommendation to give a seamless finish.
- 11.2.6 Perimeter channels are levelled at the required position of the finished ceiling line and fixed to the wall at 610 mm centre with the screws and nylon plugs. The remaining G.I. grid component are installed to form a regular grid suspended from the soffit of RCC slab using soffit cleats ceiling angle and anchor fasteners as specified. Extra frame for various cut-outs of different shapes, light fittings, AC grills, diffusers, smoke detectors and other necessities have to be provided frame work has to be made with perimeter channel of specified size and shall be suitably supported. The line and level of the grid work has to be checked for perfection and prior clearance of the grid work has to be checked for perfection and prior clearance of the grid work has to be obtained from the PMC/Employer before the

placement of Gyp board.

11.2.7 The Gyp board are fixed with bound edges at right angles to ceiling section with all joints staggered. All joints of Gyp board have to be fixed on ceiling section. The Gyp boards are screwed to the ceiling section and perimeter channels with Gyp board dry wall screws with joints staggered. Spotting of screws and jointing are then carried out according to recommendations of Saint Gobain India Gypsroc or equivalent make to give a flush and smooth joint.

11.2.8 Necessary door openings of hinged type of suitable sizes has to be provided with a suitable frame work for control valves and for access above false ceiling / AC duct boxing at not extra cost. Joints at horizontal, vertical and inclined surfaces shall be suitably strengthened with additional G.I. frame work as required. Finally the boards are jointed and finished so as to have a flush look which includes fling and finish in the tapered and square edges of the board with a jointing compound, paper tape and two coats of primer suitable for gyp board (all as per recommended practices of Saint Gobain Indian Gyproc or equivalent). The rate shall includes providing all materials, erecting, suspending, G.I. grid work, jointing the boards, providing required cut-outs and open able doors and painting including providing necessary fittings and fixtures etc. complete as per the specifications and all other activities related to the completion of the above job.

11.2.9 Details of A.C. grills, diffusers, and recessed type electrical fittings to be erected in false ceiling will be as per specifications and as shown in drawings. The quantities indicated are approximate and is likely to vary depending upon the site conditions.

11.3 WORKMANSHIP

Finishing ceiling shall be at the correct plans and present a pleasing and uniform appearance free from sags, wraps, figures or damaged joint exposed grid etc. shall be in true lines and symmetrically placed in manner shown on drawings or as recommended by manufacturers. All the cut out for light fixtures, diffusers etc. shall be exact dimensions and in exact locations as shown in respective drawings. All works in this section shall be performed in an efficient manner by installers approved by the manufacturers.

11.4 MODE OF MEASUREMENT

Measurements will be made on flat plan area basis in Sq.m calculated to 3 places of decimal. Length and breadth shall be measured corrected to a cm. No deduction shall be made for cut-outs made for A.C. grills, diffusers, electrical fittings, smoke detectors etc.

11.5 RATES

Rate to be inclusive of providing and fixing of angle beads at external angles to achieve straight line finish and protection from normal impacts. Rate to be also inclusive of providing and fixing of edge bead essential for the exposed edge of the Gypboard at the cut-outs for tube lights or any other such unprotected core. Rate to be inclusive of making of Cut- outs for Light fittings, grills, diffusers etc. All the rates shall be inclusive of all level differences / coves, etc. as per design and supply - installation of full system with necessary fixtures and fasteners when made to merge with different type of ceiling. Scaffolding is to be included in the rate and will not be paid separately

12 SHUTTERS AND DOORS**13.1 SCOPE**

The specifications refer to wood work in general including carpentry and joinery work in the building.

13.2 GENERAL

The provision of the latest revisions of the following I.S. codes shall form a part of these specifications.

IS 205	Specifications for non-ferrous metal butt hinges
IS 287	Recommendation for maximum permissible moisture content of timber used for different purposes.
IS 303	Specification for plywood for general purpose.
IS 362	Specification for parliamentary hinges
IS 419	Specification for putty for the use on window frames
IS 883	Code of practice for design of structural timber in building.
IS 1003	Specification for Timber panelled and glazed shutters Part II - Window and ventilator shutters.
IS1200	Method of measurement of building and Civil Part XXI Engineering Works - Wood Work and Joinery.
IS:1341	Specification for steel butt hinges
IS:1658	Specification for Fibre Hard Boards
IS: 1761	Specification for transparent sheet glass for glazing and framing purposes.
IS: 3087	Specification for wood particle boards (medium density for structural timber in building)

Other I.S. codes not specifically mentioned here, but pertaining to wood work and joinery form part of these specifications.

13.3 MATERIALS**13.3.1 SAWN TIMBER**

The timber shall be free from decay, fungal growth, boxed heart, pitch pockets or streaks on the exposed edges, splits and cracks. The timber shall be graded as first grade and second grade on the basis of the permissible defects in the timber. For both the grades, knots should be avoided over a specified limit. Timber is classified as under :

- (i) Teak wood
- (ii) Deodar wood
- (iii) Non-coniferous timbers other than teak
- (iv) Coniferous timber other than deodar.

13.3.1.1 Teak Wood (Tectona Grandis)

It is of outstanding merit in retention of shape and durability. The heart wood is one of the most naturally durable woods of the world. It usually remains immune to white ant attack and insect attack for very long periods. It is, however, not always immune from fungus attack (rot). Taken as a whole, good quality teak is very durable, it is relatively easy to saw and work. It can be furnished to a fair surface and takes polish well. It is generally used for making furniture and all important timber construction.

13.3.1.2 Superior Class Teak Wood such as Balarsha, Malabar and Dandeli

Individual hard and sound knot shall not be more than 12 mm in diameter and the aggregate area of all the knots shall not exceed one half per cent of the area of the piece. It shall be close grained.

13.3.1.3 Deodar Wood (Cedrus Deodars)

It is the strongest of the Indian conifers. Its weight and strength is 20% per cent less than teak. It is easy to saw and works to a smooth finish. It is not, however, a suitable wood for polish or paint work as the oil in the wood and especially near knots, always seeps through such finishes and discolours them. It is used for house building, furniture and other construction work. It is also suitable for beams, floors, boards, posts, window frames and light furniture etc.

13.3.1.4 Sal Wood (Shoera Robusta)

Sal is about 30 per cent heavier than teak, 50 per cent harder, and about 20 to 30 per cent stronger. In shock resistance it is about 45 per cent above teak. Its heart wood is a naturally durable wood, and usually remains immune to attack by white ants and fungi for a long period, while its sapwood is very perishable and should not be used. Well dried sal is not a really easy wood to saw and work. It is a rough constructional wood than a carpentry timber. No individual hard and sound knot shall exceed 25 mm in diameter and the aggregate area of all the knots shall not exceed 1% of the area of the piece. It can be used for a variety of purposes, such as for beams, rafters, flooring, piles, bridging, tool handles, picker arms and tent pegs, etc.

13.3.1.5 Kail Wood (Pinus Roxburghie)

Kail Wood is not a very durable wood. But it is easy to saw and work and usually very popular in workshops. It can be brought to a fine smooth surface, but is more suitable for paint and enamel finishes than for polish work. It is useful for joinery works, constructional work, light furniture and house fitments. All wood to be FSC (Forest Stewardship Council) certified Forests certified to be in compliance with the standards endorsed by the Forest Stewardship Council (FSC).

Products milled or otherwise altered by manufacturers certified to be in compliance with the standards endorsed by the Forest Stewardship Council (FSC).

13.3.2 GLAZING MATERIALS**13.3.2.1 Glass Panels**

Unless otherwise specified, glass panes used in glazed or panelled and glazed shutters, shall be of good quality glass of thickness not less than 2 mm for panes up to 0.1 Sqm in area not less than 3 mm for glass panes of area larger than 0.1 Sqm with a tolerance of 0.2 mm in both cases. The glass shall be free from flaws such as specks, bubbles, smoke waves, air holes, etc. and shall conform to the relevant IS : 1761.

Unless otherwise specified, glass panes used in shutters of bath room and lavatories shall be frosted and of thickness as mentioned above and shall be free from any flaws.

Where so specified, special quality glass such as plate glass, pin heads glass, wired glass, float glass etc. shall be used. They shall conform to relevant IS standards as regards quality.

13.3.2.2 Putty for glazing in wooden frames of doors and windows

Putty shall be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled linseed oil and mixing the whole thing into a homogeneous stiff paste. It shall be free from impurities like dust, grit, etc. and shall conform to IS : 419.

13.4 FITTINGS

The item of wood work of joinery generally includes fittings such as hinges and screws for fixing of door shutters and is explicitly so mentioned in the item.

Hinges - Hinges shall be of iron, brass, aluminium or any other material as specified. They shall present a neat appearance and shall operate smoothly. All hinges shall be of steel and their riveted heads shall be well formed and smooth. Hinges shall be of the type specified and shall conform to the relevant Indian Standard Specifications.

13.5 FRAMING

Framed woodwork includes all sawing, cutting, planning, jointing framing, supply and use of straps, bolts holdfasts, nails treenails, spikes, screws etc. necessary for framing and fixing. Framing and trussing are to be done in the best possible manner. Holes of correct size shall be drilled before inserting screws. Driving in or starting the screws with hammer is prohibited. All screws shall be dipped in oil before being inserted in the wood. The kind of nails and screws shall be subject to the approval of the PMC/Employer.

13.6 SCAFFOLDING

The Contractor shall provide all labour, scaffolding ladders and tackle necessary for hoisting and fixing woodwork in position and afford facilities for its inspection during construction. The Contractor shall be responsible for the safety of the work, workmen and for any action or compensation that may arise in this connection.

13.7 IRON WORK

All iron work connected with woodwork which is going to be embedded in masonry shall before erection, receive two coats of hot coal tar. If it is to be painted, it shall be given the first two coats on the ground before being fixed in position and the third coat after erection in position.

13.8 PRECAUTIONS AGAINST FIRE

During the progress of work all shavings, cutting and other rubbish shall be cleared away as the work progresses and all precautions shall be taken against fire.

13.9 INSPECTION

All woodwork shall be inspected and passed by PMC/Employer before being put into actual position. In no case the woodwork shall be painted or otherwise treated before it is inspected and approved by the PMC/Employer. After approval it shall have the primary coat of paint put on or otherwise treated before being fitted in position. The subsequent coats of paint or other finish shall be applied after the woodwork is fixed in position.

13.10 DEFECTIVE WORK

If within three months after the work is completed any undue shrinkage or bad workmanship is discovered the Contractor shall forthwith replace or refix the same to the satisfaction of the PMC/Employer, without extra charge.

13.11 MOISTURE CONTENT

Control on moisture content of timber is necessary to ensure its proper utility in various climatic conditions. For specifying the permissible limit of moisture content in the timber the country has been divided into four climatic zones. In each of the zones, maximum permissible limit of moisture content of timber for different uses, when determined in accordance with the shall be as per Table

Maximum Permissible Moisture Content of Timber

Sl.No.	Use	Max Moisture Content Percent			
		Zone	Zone	Zone	Zone
		I	II	III	IV
1.	Beams, Rafters and Posts	12	14	17	20
2.	Doors and windows				
	(a) 50 mm and above thickness	10	12	14	16
	(b) Thinner than 50 mm	8	10	12	14
3.	Flooring strips	8	10	10	12
4.	Furniture and Cabinet making	10	12	14	15

TOLERANCE ON MOISTURE CONTENT

Average Moisture content of all the samples from a lot shall be within + 3 per cent and moisture content of individual samples within + 5 per cent of maximum permissible moisture content specified in Table. These tolerance are the absolute values over the percentage moisture content for Sl. No. 1 and 2 of Table. No tolerance on moisture content is permitted for Sl. No. 3 and 4 of Table.

13.12 SEASONING OF TIMBER

The process of drying timber under controlled conditions is called seasoning of timber. Timber shall be either air seasoned or kiln seasoned and in both cases moisture content of the seasoned timber shall be as specified in Table 9. 2 above unless otherwise specified, air seasoned timber shall be used. Kiln seasoning of timber, where specified, shall be done as per IS 1141 in a plant approved by PMC/Employer.

13.13 PRESERVATION OF TIMBER

Preservative treatment does not improve basic properties of timber but gives varying degree of protection against deterioration due to attacks by fungi, termites, borers and marine organisms. Preservative treatment, where specified, shall be done using Oil type, Organic solvent type or Water-soluble type preservative. Oil type preservatives shall be used if the timber is not required to be polished or painted. Before preservative treatment, the timber shall be sawn and seasoned. All surfaces exposed after treatment, except due to planing, shall be thoroughly brushed with the preservation before jointing. Preservative treatment of timber shall be done as per IS 401 in a plant approved by the PMC/Employer.

13.14 WORKMANSHIP**13.14.1 WOOD WORK, WROUGHT, FRAMED AND FIXED****13.14.1.1 General**

The work shall be carried out as per detailed drawings and/or as directed by the PMC/Employer. The wooden members of the frame shall be planed smooth and accurate to the full dimensions. Rebates, rounding, mouldings, etc. as shown in the drawing shall be done before the members are joined into frames. Where wood work is not exposed to view as in the case of frames for false ceiling, however, no planning is required to be done unless specified expressly as rough timber work.

Note: The work wrought shall mean 'planed'.

13.14.1.2 Jointing in timber frames must be made carefully and accurately. They shall be strong, neat and shall fit without edging or filling. The joints shall be pinned with hard wood or bamboo pins of 10 to 15 - dia after the members of the frame are pressed together in a suitable vice-mechanism

13.14.1.3 The door and window frame shall have rebate to house the shutters and the depth of such rebate shall be 1.25 cm. Timber for door, window and ventilators frames shall be as specified. Timber shall be sawn in the direction of the grains. All members of a frame shall be of the same species of timber and shall be straight without any warp or bow. Frames shall have smooth, well-planed (wrought) surfaces except the surfaces touching the walls, lintels, sill etc., which may be left clean sawn. Rebates, rounding or moulding shall be done before the members are jointed into frames. The depth of the rebate for housing the shutters shall be 15 mm, and the width of the rebates shall be equal to the thickness of the shutters. A tolerance of ± 2 mm shall be permitted in the specified finished dimensions of timber sections in frames.

13.14.1.4 Wood work shall be painted, oiled, polished or otherwise treated as specified. All portions of timber abutting against masonry or concrete portion of building shall be coated with boiling coal tar or other type of approved wood preservatives primer, before placing them in final position. Before any surface treatment is applied in the wood work shall be got approved by the PMC/Employer. The Jamb posts shall be through tenoned in to the mortise of the transoms to the full thickness of the transoms and the thickness of the tenon shall be not less than 2.5 cm. The tenons shall closely fit into the mortise without any wedging or filling. The contact surface of tenon and mortise before putting together shall be glued with polyvinyl acetate dispersion based adhesive conforming to IS 4835 or adhesive conforming IS 851 and pinned with 10 mm dia hard wood dowels, or bamboo pins or star shaped metal pins. The joints shall be at right angles when checked from the inside surfaces of the respective members. The joints shall be pressed in position. Each assembled door frame shall be fitted with a temporary stretcher and a temporary diagonal brace on the rebated faces.

13.14.1.5 Fixing in Position

The frames shall be fixed only after acceptance by the PMC/Employer. In case of door frames without sills, the vertical members shall be buried in floor for the full thickness of the floor and the door frame shall be temporarily braced at the sill level so as to prevent warping or distortion of frame during construction. The frames shall be got approved by the PMC/Employer before being painted, oiled or otherwise treated and before fixing in position. The surface of the frames abutting masonry or concrete and the portions of the frames embedded in floors shall be given a coating of coal tar. Frames shall be fixed to the abutting masonry or concrete with holdfasts or metallic fasteners as specified Hilti or equivalent make. After fixing, the jamb posts of the frames shall be plugged suitably and finished neat. Vertical members of the door frames shall be embedded in the floor for the full thickness of the floor finish and shall be suitably strutted and wedged in order to prevent warping during construction. A minimum of three hold fasts shall be fixed on each side of door and window frames one at centre point and other two at 30 cm from the top and bottom of the frames. In case of window and ventilator frames of less than 1 m in height two hold fasts shall be fixed on each side at quarter point of the frames. Hold fasts and metallic fasteners shall be not be measured and paid for separately.

13.14.2 PANELLED, GLAZED OR PANELLED AND GLAZED SHUTTERS

13.14.2.1 General

The work shall be carried out as per detailed drawing. The wooden members shall be planed smooth and accurate. They shall be cut to the exact shape and sizes without patching or plugging of any kind. Mouldings, rebates, rounding, etc. shall be done, as shown in the drawing, before the pieces are assembled into the shutter.

13.14.2.2 Joinery work

The thickness of the styles and rails shall be as specified in the item of work. The minimum thickness of panels shall normally be 15 mm where the clear width of panel is not more than 300 mm and 20 mm where the clear width of the panel is more than 300 mm. However, where the PMC/Employer so considers lesser thickness up to 12 mm and 15 mm respectively may be allowed by him instead of 15 mm and 20 mm specified above. Solid wood panel for door and window shutters shall be made out of one or more strips of timber planks of not less than 125 mm width. It is preferable to use strips of not more than 200 mm width to reduce chances of warping, splitting or other defects. The timber strips shall be joined together with continuous tongued and grooved joints, glued together and reinforced with metal dowels. The grooving of the solid panel shall normally run along the longer dimensions of the panel unless otherwise directed. The corners and edges of panels shall be finished as shown in the drawing and these shall be feather tongued into styles and rails. Sash bars shall have mitres joints with the styles.

Styles and rails of shutters shall be made out of single piece. Lock and intermediate rails exceeding 200 mm in width if permitted by the PMC/Employer may be made out of one or more pieces of timber but the width of each piece shall not be less than 125 mm. Where more than one piece of timber is used, they shall be joined with a continuous tongued and grooved joint glued together and reinforced with metal dowels (rust proof) at regular intervals of 20 cm or pinned with not less than three 40 mm rust proof pins of the lost head type.

The tendons shall pass clear through styles. The styles and rails shall have a 12 mm groove to receive the panel.

In case the double shutters the rebate at the closing junction of the two shutters shall be of depth not less than 2 cm.

Shutters shall not be painted or otherwise treated before these are passed by the PMC/Employer and fixed in position.

13.14.2.3 Glazing

The glazing work shall be done in accordance with the specification given separately elsewhere.

13.14.2.4 Hold Fast

Hold fasts used for fixing doors and window frames shall be made of 40 x 3 mm flat iron and 40 cm long. It shall have two holes on one end for fixing to frame with long screws, and at the other end, the flat iron shall be split and bent at right angles in the opposite direction. The hold fast shall be tightly fixed to the frame by means of bolts, the bolt hole in frame being plugged suitably and finished neat. The hold fast shall be embedded into masonry by concrete block of 200 x 250 x 400 mm size.

13.14.2.5 Measurements

Unless otherwise specified in the BOQ, Woodwork and joinery work shall be measured in cubic meters. Length and width of unfinished opening shall be measured to the nearest 0.01 m.

Volume shall be worked out correct up to 3rd place of decimal of a Cum. All work shall be measured net as fixed, that is, no extra allowance in measurement shall be made for shape, joints, etc. However, where the dimensions as fixed exceeds the specified dimension (as per drawing, etc.) only the

specified dimensions(s) shall be measured and where one or more dimension of the piece as fixed is less than the fixed dimension the actual dimension shall be measured, without prejudice to the right of the PMC/Employer to reject the piece and order replacement of such pieces.

It shall include:

- a) Supply of specified species of timber sawn to requisite sizes without any defect, wrought, framed and fixed in position with the required standard of workmanship including supply-and-fixing of fixtures, straps, bolts, hold-fasts, spikes, nails, screws, etc. applying contractors glue or other jointing materials, coal tarring embedded parts, glazing and supplying and fixing of all specified fittings.
- b) All material, labour, scaffolding, use of equipment etc. for framing, fixing and completing the item as specified.

13.14.3 FLUSH DOOR SHUTTER

13.14.3.1 General

The door shall be of flush type solid core with single or double shutter as the case may be.

13.14.3.2 Shutters

Flush door shutters shall have a solid core and may be of the decorative or non-decorative (Paintable type as per IS 2202 (Part I). Nominal thickness of shutters may be 25, 30 or 35 mm. Thickness and type of shutters shall be as specified.

Width and height of the shutters shall be as shown in the drawings or as indicated by the PMC/Employer. All four edges of the shutters shall be square. The shutter shall be free from twist or warp in its plane. The moisture content in timbers used in the manufacture of flush door shutters shall be not more than 12 per cent when tested according to IS 1708.

13.14.3.3 Core

The core of the flush door shutters shall be a block board having wooden strips held in a frame constructed of stiles and rails. Each stile and rail shall be a single piece without any joint. The width of the stiles and rails including lipping, where provided shall not be less than 45 mm and not more than 75 mm. The width of each wooden strip shall not exceed 30 mm. Stiles, rails and wooden strips forming the core of a shutter shall be of equal and uniform thickness. Wooden strips shall be parallel to the stiles.

13.14.3.4 End joints of the pieces of wooden strips of small lengths shall be staggered. In a shutter, stiles and rails shall be of one species of timber. Wooden strips shall also be of one species only but it may or may not be of the same species as that of the stiles and rails. Any species of timber may be used for core of flush door. However, any non-coniferous (Hard wood) timber shall be used for stiles, rails and lipping.

13.14.3.5 Face Panel

The face panel shall be formed by gluing, by the hot-press process on both faces of the core, either plywood or cross-bands and face veneers. The thickness of the cross bands as such or in the plywood shall be between 1.0 mm and 3.0 mm. The thickness of the face veneers as such or in the plywood shall be between 0.5 mm and 1.5 mm for commercial veneers and between 0.4 mm and 1.0 mm for decorative veneers, provided that the combined thickness of both is not less than 2.2 mm. The direction of the veneers adjacent to the core shall be at right angles to the direction of the wooden strips. Finished faces shall be sanded to smooth even texture. Commercial face veneers shall conform to marine grade plywood and decorative face veneers shall conform to type I decorative plywood in IS 1328.

13.14.3.6 Lipping

Lipping, where specified, shall be provided internally on all edges of the shutters. Lipping shall be done with battens of first class hardwood or as specified of depth not less than 25 mm. For double leaved shutters, depth of the lipping at meeting of stiles shall be not less than 35 mm. Joints shall not be permitted in the lipping.

13.14.3.7 Rebating

In the case of double leaves shutters the meeting of stiles shall be rebated by 8 mm to 10 mm. The rebating shall be either splayed or square type as shown in drawing where lipping is provided. The depth of lipping at the meeting of stiles shall not be less than 30 mm.

13.14.3.8 Opening for Glazing

When required by the purchaser opening for glazing shall be provided and unless otherwise specified the opening for glazing shall be as per drawings. The bottom of the opening shall be at a height as shown in the drawings. Opening for glazing shall be lipped internally with wooden batten of width not less than 25 mm. Opening for glazing shall be provided where specified or shown in the drawing.

13.14.3.9 Tolerance

Tolerance on width and height shall be + 3 mm and tolerance on nominal thickness shall be ± 1.2 mm. The thickness of the door shutter shall be uniform throughout with a permissible variation of not more than 0.8 mm when measured at any two points.

13.14.3.10 Adhesive

Adhesive used for bonding various components of flush door shutters namely, core, core frame, lipping, cross-bands, face veneers, plywood etc. and for bonding plywood shall conform to BWP type, phenol formaldehyde synthetic resin adhesive conforming to IS 848.

13.14.3.11 Tests

Samples of flush door shutters shall be subjected to the following tests:

- a) End Immersion Test
- b) Knife Test
- c) Glue Adhesion Test

13.14.3.12 Fixing

For side hung shutters of height up to 1.2 m, each leaf shall be hung on two hinges at quarter points and for shutter of height more than 1.2 m, each leaf shall be hung on three hinges one at the centre and the other two at 200 mm from the top and bottom of the shutters. Top hung and bottom hung shutters shall be hung on two hinges fixed at quarter points of top rail or bottom rail. Centre hung shutter shall be suspended on a suitable pivot in the centre of the frame. Size and type of hinges and pivots shall be as specified. Flap of hinges shall be neatly counter sunk into the recesses cut to the exact dimensions of flap. Screws for fixing the hinges shall be screwed in with screw driver and not hammered in. Unless otherwise specified, shutters of height more than 1.2 mm shall be hung on butt hinges of size 100 mm and for all other shutters of lesser height butt hinges of size 75 mm shall be used. For shutter of more than 40 mm thickness butt hinges of size 125 × 90 × 4 mm shall be used. Continuous (piano) hinges shall be used for fixing cup-board shutters where specified. Fittings shall be provided as per

schedule of fittings decided by Architect Cost of providing and fixing shutter shall include cost of hinges, door closer, handle, lock and necessary screws for fixing the same. The fittings shall conform to specifications laid down under the hardware list which is coming up in the document later. Where the fittings are stipulated to be supplied by the Client free of cost, screws for fixing these fittings shall be provided by contractor and nothing extra shall be paid for the same.

13.14.3.13 Measurements

Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Overlap of two shutters shall not be measured. The overall openings to be measured in case the doors are paid in Nos

13.14.4 FIRE RATED / GENERAL PURPOSE STEEL DOOR

13.14.4.1 Scope

This specification covers the design, supply of materials, manufacture and installation of factory made type fire rated steel doors with 1 (one) Hour or 2 (two) Hours fire rating / General purpose Steel Door of approved make with different rating as per the requirements with all accessories, hard wares, iron Mongery, fastening materials and including installation of door with hard wares in position.

13.14.4.2 General requirements

The Nominated sub Contractor shall furnish all materials, labour, operations, equipment, tools and plant, scaffolding and incidentals necessary and required for the completion of metal work in connection with steel doors, as called for in the drawings, specifications and bill of quantities which cover the major requirements only. Anything called for in the tender documents shall be considered as applicable to the items of work concerned. The supply and installation of additional fastenings (Metal expansion Shields), accessory features and other items not specifically mentioned, but which are necessary to make a complete functioning installation shall form a part of this contract.

All metal work shall be free from defects, impairing strength, durability and appearance and shall be of the best quality for purposes specified made with structural properties to withstand safety strains, stresses to which they shall normally be subjected to. All Hard ware fittings and Accessories shall be of high quality and as specified and as approved by the Employer / OE and PMC.

The Nominated sub Contractor shall strictly follow, at all stages of work, the stipulations contained in the Indian Standard Safety Code and the provisions of the safety code and the provision of the safety rules as specified in the General Conditions of the Contract for ensuring safety of men and materials.

Any approval, instructions, permission, checking, review, etc. whatsoever by the Employer / OE and PMC, shall not Relieve the Nominated sub Contractor of his responsibility and obligation regarding adequacy, correctness, completeness, Safety, strength, quality, workmanship, etc.

The Nominated sub Contractor shall submit the Shop drawing for all works including all details, and after check by his own Engineer. The Nominated sub Contractor shall not commence the work before obtaining prior and final approval for shop drawings incorporating the changes, if any, instructed by the Employer / OE and PMC. Such prior approval shall not relieve the Nominated sub Contractor from his responsibility of correctness of design, workmanship and material errors and omissions, if any.

13.14.4.3 CODES AND STANDARDS

All standards, specifications, acts, and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.

List of certain important Indian Standards, Acts and Codes applicable to this work is given below. However, the applicable standards and codes shall be as per this but not limited to the list given below:

IS : 277	Galvanized steel sheet (plain and corrugated) of GPL Grade Z 120 coating.
IS: 3614 Part 1 and 2/ BS 476 Part 20 and 22	Metallic and non-metallic fire check doors - Resistance test and Performance criteria.
BS 7352 /BS EN 1935	Specification of Hinges

13.14.5 HOLLOW METAL FIRE DOOR / GENERAL PURPOSE DOOR WITH IN FILL MATERIAL AS PER MANUFACTURER'S SPECIFICATION.

Fire door shall be 1 Hour / 2 hour fire rated and door quality shall be approved by CBRI and the door should be tested to conform the Performance Criteria as per IS: 3614 and should meet the requirements of CBRI. General purpose Door shall be as per Manufacturer's specification. Unless otherwise specified, the door shall be provided to the height of 2100 mm. If the height specified as above 2100 mm and up to 3000 mm height, the options would be:

- A man operation door up to 2100 mm high shall be provided with a removable / fixed panel on top as below: (i.e. above 2100 mm level as below).
- Fire Door: Fully flush double skin steel panel construction to a total thickness of 46 mm.
- General purpose Door: Fully flush double skin steel panel construction to a total thickness of 46 mm or fixed Glazing Panel on the top with Single / Double glass panel.

The construction and finish of panel above 2100 mm level shall be designed similar to that of a shutter in case of flush panel in order to match the exterior finish.

13.14.5.1 Door frame

Material

Frame shall be manufactured by using Galvanized steel sheets complying with latest IS 277. Galvanized coating shall be GPL grade Z 120 coating.

Profile:

Fire Door and General Purpose door frame profile shall be as given below:

Fire Door - 2 Hour rating: Double rebate profile of size 143 x 57 mm (+/- 0.3) with bending radius of 1.4 mm.

Fire Door - 1 Hour rating: Single rebate profile of size 100 x 57 mm (+/- 0.3) with bending radius of 1.4 mm.

General Purpose Door: Single rebate profile of size 100 x 57 mm (+/- 0.3) with bending radius of 1.4 mm.

Manufacture :

Frame shall be fabricated from galvanized steel sheet to the thickness specified below and to the specified profile and dimensions:

- Fire Door - 2 Hour rating : 16 Gauge or 1.6 mm thick.
- Fire Door - 1 Hour rating : 18 Gauge or 1.25 mm thick.
- General Purpose Door : 18 Gauge or 1.25 mm thick.

Frames fabricated at factory shall be in knock down form with butt joints for bolted assembly at site or as per manufacturer's Specification.

Preparation:

Frames shall be provided with 3 mm thick back plates on all jambs with provision for anchor bolt fixing to wall openings.

Frames shall be provided with hinge plates 3 mm thick pre-drilled to receive approved type and make of hinges for screw mounted fixing.

Frames shall have factory finish-pre-punched cut outs to receive specified type and make of hardware and iron Mongery. All cut outs including hinge plates, strike plates to have mortar guard covers from inside to prevent cement, dust ingress into cut outs at the time of grouting of the frame.

Frames shall have reinforcement pads for fixing of door closer, locks and handles at appropriate location as per manufacturer's details.

Frames shall have plug-in type rubber silencer not less than 2 mm dia on the strike jambs for single shutter frames and on the head jambs for double shutter frames.

13.14.5.2 Door shutter

Material

- a) Shutter shall be manufactured with double skins press formed by using Galvanized steel sheets complying with latest IS 277. Galvanized coating shall be GPL grade Z 120 coating.
- b) Profile:
- c) Shutters should be press formed with double skins in such a way to get 46 mm thick double skin hollow door with lock seam joints at stile edges.

Fire Door and General Purpose door frame profile shall be as given below:

- a) Fire Door - 2 Hour rating : 18 Gauge or 1.25 mm thick.
- b) Fire Door - 1 Hour rating : 20 Gauge or 0.80 mm thick.
- c) General Purpose Door : 20 Gauge or 0.80 mm thick.

Shutters shall have no visible screws or fasteners on both face and internal reinforcement shall be provided at top, bottom and stile edges for desired fire rating.

In Fill Material

Shutters shall be provided with honeycomb paper core as infill material and to be bounded to the inner faces of the shutter or as per Manufacturer's specification. Door should have been tested with Infill material proposed by the manufacturer and the same should have been approved by CBRI.

Preparation

Shutters shall be provided with factory prepared and with pre-punched cut-outs and reinforcement pads to receive the approved type and make of Hardware and Iron Mongery. The shutter should have an interlocking arrangement at this stile edges for flat surface on either side.

Shutters shall have pre-drilled hinge plates with hinge guard covers.

Shutters with locks to have concealed lock box with lock fixing brackets with pre-tapped holes and screws.

Shutter shall have reinforcement pad at appropriate location to receive the locks, Door closer, Panic Bar, etc as per the approved type and make of Hardware and all as per manufacturer's design and conforming to Standards.

Necessary provision / fixing arrangements shall be provided in the shutter as well as in the frame to receive / fix the Electromagnetic latch, Electromagnetic contact for hooters with reinforcement pads and in such a way to connect the same to the card access control system / IBMS. Fixing Details of the above latches shall be provided in coordination with IBMS agency.

Vision panel shall be provided as given below

- a) Fire rated Door (1 Hour / 2 Hour) - Provide Borosilicate single clear toughened glass of approved equivalent make to the thickness of 6 mm to with stand two hours fire rating.
- b) General purpose Door - Provide Single / Double clear toughened glass of approved equivalent make to the thickness of 5 mm to the specified size and as per Manufacturer specification. Glass to be fixed with clip on frames for square and rectangular vision panels and with spin turned rings for circular vision panels. One side adhesive Glazing tape shall be provided in the frame to fix the vision panel glass in position and ensuring the stability of the fixing.
- c) Finish – Frame and Shutter:
- d) Surface of the frame and shutter shall be cleaned suitably and thoroughly with solvents and as

per manufacturer's specification.

- e) Apply Zinc etch primer coating as shop coat to receive additional coat of primer and top coats.
- f) Apply stove zinc phosphate primer (35 microns DFT) as additional coat.
- i) Apply as finish coat and finish the surface neatly with thermo setting polyurethane paint (35 microns DFT) of approved colour and make.

g) PACKING

- i) Individual frames members and individual shutters to be wrapped and protected with self adhesive Peel-off Polythene sheets or Co extruded PE film to a minimum thickness of 60 Microns, with low tack adhesive and with abrasion resistant for a minimum period of 6 months and UV resistant capability.

- ii) Individual frames members and individual shutters to be packed in an individual card board boxes and to be sealed with Identification numbers.

- iii) All frames and shutters shall be marked with identification number in such a way install the door according to the door schedule.

h) STORAGE

Frames shall be stacked flat and shutters shall be stacked vertically on wooden runners and suitably covered as per the manufacturer's instructions to prevent rust and damage.

a) INSTALLATION

FRAME:

- i) Door frames should be assembled adjacent to the place of installation as per the Manufacturer's specification. Frames are not allowed for transporting in an assembled condition. If the manufacturer is desired to transport the frames in an assembled condition, the frames should be designed suitably and adequate packing to be given prior to transport in order to avoid any damage, bending etc during transport. If any defects found during the installation, such frames will be summarily rejected and will not be allowed to use.

- ii) After assembly it is to be ensured that all threaded preparations / joints are covered by using 15 x 10 self adhesive sponge strips at the back of the frame to prevent penetration of grouting mortar into screw threads. The head member of assembled frame shall be positioned against jambs ensuring correct alignment and secured using M 8 x 20 mm long plated Stainless steel bolts together with nuts spring and flat washers. Frames to be assembled at site with aid of roofing bolts and the protective film shall not be removed during installation.

- iii) Assembled frame shall be kept in position within the opening by means of bracing. In order to correctly position the frame against finished floor level or equalize on adjustable floor anchors where specified, suitable strength PVC nylon shim shall be used under jambs. The frame shall be checked for square ness, alignment, twist etc. with carpenters bevel and plumb.

- iv) A tie rod shall be f

- v) ixed to the frame during installation to ensure the correct dimensions between the frame rebates and the same may be removed after installation.

- vi) Where fixing the frame is necessitated, the required gap between frame and jambs shall be created to accommodate the PVC nylon shims in such a way to maintain the uniform frame level.

- vii) Methodology to be followed during the installation of the frames:

- i) Site survey shall be conducted to ensure the opening size and reveal the correct opening size prior to installation of the frames.

- ii) Place the frame in position, brace, level etc.

- iii) Mark all positions of fixings anchors on the wall / lintel.

- iv) Remove frame and drill wall to appropriate fastener or anchor bolts size.

- v) Place and fit rod anchor shells metal expansion bolts into the wall.

- vi) Place and fit jamb spacer bracket into back of frame profile.

- vii) Reposition the frame back into opening and realign.

- viii) Lightly tighten the CSK HD machine screws into shells.

- ix) Check the position of the nylon shims placed behind frame to ensure the uniform gap between the frame and jamb.

- x) Slowly fasten the screws continually by checking the plumb, square ness etc. and finally ensure that the frames are not deformed while tightened.

- xi) After fixing the frame in position, the frame shall be pressure grouted with cement slurry 1:3

ratio or filling the pre- cast solid block core to the frame profile as approved. The surface after grouting shall be neatly cleaned and to be ensured that there is no scratch in the door frames after grouting.

- xii) Back fill the frame through holes provided and insert plug in type nylon plugs after cleaning the surface. Nylon plugs shall be provided to suit the frame finish and colour.
- xiii) Gap between the frame and masonry surface shall be grouted with cement slurry and sealed with Intumscent sealant of approved make, if called for in the Bills of quantities.

SHUTTER:

- i) Fix all the hardware to the door shutter like hinges, flush bolts, bolts, Mortise locks, Dead lock, handle, Push plate, Door closer, Door stoppers, etc. with the appropriate SS screws and bolts supplied.
- ii) The shutter is to be then fixed in to the installed frame and align the shutter to match the hardware to the cut-outs in the frame. Tighten the hinge screws.
- iii) Clean the door jamb rebate surfaces of all dust, oil etc.
- iv) Affix self-adhesive 'FLAT' seal on the door frame rebates, on hinge jambs, strike jambs, head member, sill etc and affix 'FLAT' seal in the shutter by using self adhesive EPDM smoke seal 'FLAT' type (Polyethylene cross linked foam of size 2 mm thick and 12.5 mm width) of Monarch Make and as indicated by the manufacturer and if specifically called for in the bills of quantities.

HARDWARE SCHEDULE:

Refer the Hardware Schedule enclosed along with BOQ.

b) TESTING / INSPECTION and GURANTEE:

During the process of manufacturing the Door by the agency, successful vendor shall arrange an inspection of the factory by the representative of Employer/OE and PMC/LA within the quoted rate. After installing the door, the Nominated sub Contractor shall test the performance of the Door Frame and Shutter in the presence of the Employer / OE and PMC. The doors shall be smoothly operable under all ambient conditions. All control, hardwares and locking devices shall give fault free performance.

A successful bidder shall arrange a test for one door with the specified hardware and place the door for testing in exactly the same way as fixed at site. The Employer / OE and PMC at random basis will select the door during the process or end of the manufacture and conduct the test at an approved laboratory in the presence of the representative of Employer / OE and PMC within the quoted rate and ensure that the door shall comply with the set out criteria.

Provide a Guarantee certificate and Test certificate for the tested door in an acceptable format in a stamped paper.

13.14.6 2-HOUR NON METAL FIRE RATED DOOR

2 Hours fire Non Metal fire rated doors system duly tested for integrity and Insulation as per the IS:3614 part 2 and BS:476 part 20 at FRL CBRI Roorkee with standard heating conditions as specified in IS:3809 - 1979 and BS:476 part 20 and 22 1987 to achieve the required integrity and insulation (I.e. to restrict the heat radiation, temperature rise on the non fire side to the maximum of 140 degree Celsius above the ambient temperature on the

unexposed surface of the shutter), Framework to be in Seasoned hardwood (Moisture contain limited to 18%) frame of section 150mm X 75mm with 1 nos. of approved make Intumescant strip to take care of Hot smoke size of 20mm X 2mm cancelled in the groove of the frame with fixing arrangements of 3 nos. of G.I. hold fast 225mmX20mmX4mm with split end on either side and wall grouted with cement concrete mix 1:3:6 adjustable lugs with split end tail to each jamb alternatively approved make Anchor Fastener, including 4 nos. of stainless steel ball bearing hinges of SS 304 quality of size 102mmX102mmX3mm thick to capable of taking load up to 120 Kg of the shutter with SS pin, lock strike plate, shock absorbers as specified and 56mm thick single leaf shutter made out of perimeter railing of Seasoned Red Marenti hard wood (Moisture contain limited to 18%) of size 100mmX30mm and 2 nos. of 9mm thick Promina – 60 board duly HOT PRESSED with 4mm Commercial / Marine Ply to get the require surface for Laminate/ Veneer/ Paints with 30mm thick Non-combustible Fire Retardant

compound and Fire Intumescent Seal of size 20mm x 2mm mounted in the grooves in the shutter on all sides except bottom with 10mm thick teak wood beading on all side and Intumescent sealant is used to seal the gaps between Promina-60 Board and shutter beading. The fire Doors with frame will be as per IS:3614 part 4 and BS:476 part 20 at FRL CBRI Roorkee with standard heating conditions as specified in IS:3809 - 1979 and BS:476 part 20 and 22 1987 all complete to the entire specification with the certified copy of the valid Test Certificates

13.14.7 TRAP DOOR

The trap Door should be of size as mentioned in the drawings. It should be made from 19mm marine grade plywood and finished in 1mm thick approved shade laminate on the exposed side and balancing laminate, 0.8mm thick on the underside. The edges to be in finished in 6mm thick teakwood lipping and finished in approved melamine polish. The framework should be as mentioned in the drawings. The cost should include hardware like a hatch using self-adjusting clasping springs, with a lock and hinge mechanism that is integrated in the frame corners and concealed. The system should be equipped with round cylinder lock / square bolt / lock, designed for profile cylinders Product / system. Item should include all accessories, fitments, man and material, correct installation procedure, necessary cutting in False ceiling strictly with unit template and finishing, cleaning complete.

Method and workmanship

The location of the trap door to be neatly located, surrounding surface cleaned of all dust and grime. The location and outline of the trap door should be neatly marked. This should strictly be the cut-line, any opening larger or smaller than this is not technically appropriate and may lead to malfunctioning of the Trap door. The self tapping screws provided for in the unit packing and the corresponding raul-plugs to be strictly used. Only the indicated number of screw holes and their indicated positions should be followed. The trap door is a system designed to rest on false ceiling Gypsum board. Any installation damages to false ceiling can be touched up with gypsum plaster. Post installation finishing involves neat painting touch-up to the vicinity, with masking tapes on the Trap door rim.

Working Platform and Safety

A local portable ladder of sufficient stoutness and stability should be used for reaching out to the false ceiling.

Making good

Post installation inspection should follow sufficient drying of paint and removal of masking tapes & fine touch-up if need be.

Mode of Measurement and payment

Mode of measurement should be in Sqm. Architect/Consultant certified completed units to be eligible for measurement for payment.

13.15 DOOR HARDWARE

Mortise Latch

- 1) Shall carry manufacturer's warranty of 1 year
- 2) Euro Mortise Passage Latch - Inside and Outside shall be opened by handle at all times
- 3) Shall comply with EN12209-1 and BS 5872 Standards
- 4) Shall be Tested for 5,00,000 cycles
- 5) Shall be suitable for wooden, metal and fire doors (latch functions) with 60mm standard back set
- 6) Shall be suitable for doors of thickness range 30mm to 50mm
- 7) Latch bolt, Deadbolt, Faceplate shall be made of Stainless Steel
- 8) Shall have Satin Stainless Steel finish
- 9) As an option locks may be Fire tested to GB7633 standards, CNACL certified, AS 130.4-2005 Standard
- 10) Euro Mortise Lock - Outside – Shall be opened by handle when unlocked. Lever shall withdraw latch bolt. Key shall lock or unlock bolt, key shall withdraw latch bolt. Inside – Shall be opened by handle when unlocked. Lever shall withdraw latch bolt. Key shall lock or unlock bolt, key shall withdraw latch bolt.

- 11) Euro Mortise Deadbolt - Outside - Bolt shall be locked or unlocked by key or turn. Inside - Bolt shall be locked or unlocked by key or turn
- 12) Euro Mortise Night latch – Outside – Latch bolt shall be withdrawn by key or turn. Inside – Latch bolt shall be withdrawn by key or turn.
- 13) Euro Mortise Privacy Lock – Outside – Shall be opened by handle except when bolt is thrown by turn knob from inside. Bolt may be unlocked from outside by coin or screwdriver by operating the slotted emergency button. Inside – Shall be opened by handle except when bolt is thrown by inside turn knob.

Euro Cylinder –

- 1) Shall carry manufacturer's warranty of 1 yr
- 2) Shall be of 5 pin Euro Double Cylinder
- 3) Shall be suitable to be used with Euro Profile Mortise Locks
- 4) Shall have C4 Key Profile, 70mm length and have 3 keys
- 5) Shall have Satin Chrome Finish

Euro Single Cylinder with Thumb turn –

- 1) Shall carry manufacturer's warranty of 1 yr
- 2) Shall be of 5 pin Euro Single Cylinder with Turn
- 3) Shall be suitable to be used with Euro Profile Mortise Locks
- 4) Shall have C4 Key Profile
- 5) Shall be of 65mm length
- 6) Shall have 3 keys
- 7) Shall have Satin Chrome Finish

Tubular Lever Handle –

- 1) Shall carry manufacturer's warranty of 1 yr
- 2) Tubular Lever on Rose shall be with Euro Profile Escutcheon
- 3) Shall be made of Stainless Steel Grade 304
- 4) Shall have Satin Stainless Steel Finish
- 5) Shall be tested for corrosion resistance in accordance with AS 2331.3.1 Neutral Salt Spray Test
- 6) Spray Test

Euro Profile Escutcheon or Rose –

- 1) Shall carry manufacturer's warranty of 1 yr
- 2) Euro Profile Rose material
- 3) Stainless Steel Grade 304
- 4) Satin Stainless Steel Finish
- 5) Tested for corrosion resistance in accordance with AS 2331.3.1 Neutral Salt Spray Test

Entrance Handle –

- 1) Shall carry manufacturer's warranty of 1 yr
- 2) Shall be tubular Back to Back Pull Handle
- 3) Shall have spigots to suit 10 – 12mm thick glass doors as well as spigots to suit aluminium and timber doors up to 50mm thick
- 4) Shall be made of 304 grade stainless steel construction suitable for use in external environments
- 5) Shall have Satin Stainless Steel Finis

Cylindrical lever –

- 1) Shall carry manufacturer's warranty of 1 yr
- 2) Shall be suitable for semi commercial applications such as apartments and offices
- 3) Back set shall be 60mm standard. Extension tubes shall be available for 127mm back set
- 4) Latch bolt shall be of Stainless Steel
- 5) Shall suit door thickness of 35-46mm

- 6) Shall have standard T Strike
- 7) Shall have Satin Stainless Steel finish
- 8) Shall have field changeable handing
- 9) Shall be successfully tested up to 4 hours on fire door assemblies in accordance with Australian Standards AS-1905 Part 1, fire resistant door sets

Patches –

- 1) Shall carry manufacturer's warranty of 1 yr
- 2) Shall be suitable for doors with maximum weight 80Kgs and maximum width 1100mm
- 3) Shall have Satin Stainless Steel Finish

Door stop/ Security door chain/ door guard / other door accessories–

- 1) Shall carry manufacturer's warranty of 1 yr
- 2) Shall be made of 304 Grade Stainless Steel
- 3) Shall have Satin Stainless Steel finish

Hinges–

- 1) Shall carry manufacturer's warranty of 1 yr
- 2) Stainless Steel Ball Bearing Button Tip Hinge
- 3) Shall be suitable for interior / exterior doors
- 4) Shall be with two ball bearings
- 5) Shall be manufactured of 304 Stainless Steel
- 6) Shall be with Fixed Pins of Standard Imperial Hole pattern
- 7) Shall be of size as per manufacturer's specifications
- 8) Finish shall be Satin Stainless Steel

Kick Plates–

This shall be of brass (finished bright or chromium plated or oxidised) bronze, stainless steel, aluminium or as specified. Aluminium kicking plates shall be anodised and the anodic coating shall not be less than grade AC-10 of IS 1868. It shall be made from a plate of minimum thickness 3.0 mm & 1.5mm in case of stainless steel. Shape of the plate shall be as specified. This shall have bevelled or straight edges and shall be fixed by means of counter sunk or rounded screws of the same material and finish as that of the plate. The shape and pattern shall be according to the drawings and as approved by the PMC/Employer.

13 CAVITY / FALSE FLOOR

13.1 SECTION INCLUDES

Work of this section includes, but is not limited to: access floor panels, floor coverings, under structure and various electrical, data and communication accessories.

13.2 RELATED SECTIONS

General contractor shall provide clear access, dry secure storage, and a clean sub-floor area which is free of construction debris and other trades during installation of the access floor system. Area to receive the access floor shall be enclosed and be maintained at a temperature range of 50° to 90° F (10° to 32° C) and a humidity range of 20% to 70% relative.

Concrete sealer shall be compatible with pedestal adhesive.

Electrical contractor shall provide necessary material and labor to electrically connect the access floor to the building.

13.3 REFERENCES

CISCA (Ceilings and Interior Systems Construction Association) - "Recommended Test Procedures for Access Floors" shall only be used as a guideline when presenting load performance product information.

13.4 PERFORMANCE REQUIREMENTS

Pedestals:

Axial Load: Pedestal assembly shall provide a 2200 Kg axial load without permanent deformation.

Overturning Moment: Pedestal assembly shall provide an average overturning moment of 1000 lbs. (113 Nm) when glued to a clean, sound, uncoated concrete surface. ICBO number for the specific system or structural calculations shall be required attesting to the lateral stability of the system under seismic conditions.

Floor Panels:

Concentrated Load: Panel shall be capable of supporting a concentrated load of 450kgs placed on a one square inch area (645.16 mm²) (using a round or square indenter) at any location on the panel with a maximum top surface deflection of 0.100 inches (2.54 mm). Panel shall not exceed a permanent set of 0.010 inches (0.25 mm), after the load is removed. Panel shall demonstrate ductility by being loaded to a deflection of 0.100 (2.54 mm) inches without incurring damage.

Uniform Load: Panel shall be capable of supporting a uniform load of 1350 kg per Sqm. Placed on a one square foot area at any location on the panel with a maximum top surface deflection of 0.060 inches (1.52 mm). Panel shall not exceed a permanent set of 0.010 inches (0.25 mm), after the load is removed. **Note: The uniform load rating of an access floor panel as specified herein should not be confused with the "uniform live load" as specified in seismic zone applications.**

Ultimate Load: Panel shall be capable of withstanding a concentrated load of 3250 lbs. (14.45 Kn) or as per manufacturer's specifications applied onto a one square inch area (645.16 mm²) (using a round or square indenter) **at any location on the panel** without failure. Failure is defined as the point at which the panel will no longer accept the load. Certified test report shall be provided attesting to this ultimate load.

Rolling Load: Panel and supporting under structure shall be able to withstand the following rolling loads at any location on the panel without developing a local and overall surface deformation greater than 0.040 inches (1.01 mm).

Impact Load: Panel and supporting under structure shall be capable of supporting an impact load of 100 lbs (or as per manufacturer's specifications). (0.44 Kn) dropped from a height of 12 inches (304.8 mm) onto a one square inch area (645.16 mm²) (using a round or square indenter) at any location on the panel, after which it shall continue to meet all load performance requirements as previously defined.

Panel Drop Test: Panel shall be capable of being dropped face up onto to a concrete slab from a height of 36" (914.4 mm), after which it shall continue to meet all load performance requirements as previously defined.

Panel Cut-out: Panel with 8" (203.2 mm) diameter cut-out shall be capable of withstanding an ultimate load without failure of 1500 lbs. (6.67 Kn) anywhere on the panel.

13.5 DESIGN REQUIREMENTS

Access floor system, where indicated on the design documents, shall consist of modular and removable cementitious filled welded steel panels fastened onto, and supported by, adjustable height pedestal assemblies. Pedestal head and panel corner design must provide a positive location and lateral engagement of the panel to the under structure support system without the use of fasteners.

Panel shall be easily removed by one person with a lifting device and shall be interchangeable except where cut for special conditions.

Quantities, finished floor heights (FFH) and location of accessories shall be as specified on the contract drawings. The Finish Floor Height to be 150mm.

13.6 SUBMITTALS FOR REVIEW

Detail sheets, for each proposed product type, which provide the necessary information to describe the product and its performance.

Test reports, by an independent testing laboratory, certifying that component parts perform as specified.

13.7 SUBMITTALS FOR INFORMATION

Manufacturer's installation instructions and guidelines.

Manufacturer's Owner Manual outlining recommended care and maintenance procedures.

13.8 SUPPORT COMPONENTS

Pedestals:

Pedestal assemblies shall be corrosive resistant, all steel welded construction, and shall provide an adjustment range of +/- 1" (25.4 mm) for finished floor heights 6" (152.4 mm) or greater.

Pedestal assemblies shall provide a means of levelling and locking the assembly at a selected height, which requires deliberate action to change height setting and prevents vibration displacement.

Pedestal head shall be designed with locating tabs and integral shape to interface with the panel for positive lateral retention and positioning without fasteners.

Note: This allows the floor to be installed during the construction process without screws so that access by other related trades can be accomplished quickly and easily. It also enables the user to have a mixed installation of fastened and unfastened panels within the same installation.

Galvanized steel pedestal head shall be welded to a threaded rod which includes a specially designed adjusting nut. The nut shall provide location lugs to engage the pedestal base assembly, such that deliberate action is required to change the height setting.

Threaded rod shall provide a specially designed anti-rotation device, such that when the head assembly is engaged in the base assembly, the head cannot freely rotate (for FFH of 6" (152.4 mm) or greater).

Note: This prevents the assembly from inadvertently losing its levelling adjustment when panels are removed from the installation during use.

Pedestal base assembly shall consist of a formed galvanized steel plate with no less than 16 inches (406.4 mm) of bearing area, welded to a 7/8" (22.09 mm) square galvanized steel tube and shall be designed to engage the head assembly.

13.9 PANEL COMPONENTS

Floor Panels:

Panls shall consist of a top steel sheet **welded** to a formed steel bottom pan filled internally by a lightweight cementitious material. **Mechanical or adhesive methods for attachment of the steel top and bottom sheets is unacceptable.**

Cementitious fill material shall be totally encased within the steel welded shell except where cut for special conditions. **Note: This greatly reduces the potential for dust in the environment from exposed cement materials.**

Panel shall have an electrically conductive epoxy paint finish.

Corner of panel shall have a locating tab and integral shape design to interface with the pedestal head for positive lateral retention and positioning with or without fasteners.

Fastening of panels to pedestal heads shall be accomplished by the use of a machine screw which is specially designed to be self capturing within the body of the panel. **Note: This prevents the inadvertent loss of panel fastening screws when accessing the under floor space and potential damage to objects by screws which extend beyond the depth of the panel.**

Top surface of the panel **shall have option** for four positioning location holes to engage positioning buttons on the carpet tile for precise matching of the carpet tile to the panel.

Fit between the pedestal head, panel, and screw shall enable an installation with an average panel to panel gap of 0.015" (0.38 mm).

13.10 ACCESSORIES

Manufacturer's listed access floor outlet boxes shall be provided in locations as detailed on the contract drawings. Large capacity 11 ¼ inch (285.75 mm) square service outlet boxes shall be capable of accommodating four duplex receptacles, six individual voice/data termination points and one grommet port. Standard capacity 7-5/16 (185.67 mm) by 6-15/16 (176.02 mm) inch service outlet boxes shall be capable of accommodating two duplex receptacles, two individual voice data/termination points and one grommet port. The service outlet box shall be a drop-in design having a hinged Lexan lid with carpet insert and Lexan frame with tapered edge. Service outlet box shall be capable of withstanding without failure an 800 lb. (3.55 Kn) load.

Provide manufacturer's standard steps, ramps, fascia plate, perimeter support, and grommets where indicated on the contract drawings.

13.11 FINISHES

Finish the surface of floor panels with floor covering material as indicated on the contract drawings. Where floor coverings are by the access floor manufacturer, the type, colour and pattern shall be selected from manufacturer's standard.

Carpet tile: Access floor system shall be designed to accommodate a modular carpet tile. This is accomplished utilizing four precisely located positioning buttons on the carpet tile which engage into four positioning location holes within the top surface of the access floor panel. The carpet tile's durable backing maintains dimensional stability, and holds the carpet tile flat without adhesives. Adhesives are not necessary and shall not be permitted on the Positile installation except where the carpet is cut and more than two positioners are removed.

Vinyl edge trim for high pressure laminate and all other tile coverings shall be shall be applied to the panel's top surface and shall not wrap around the panel's edge.

13.12 FABRICATION TOLERANCES

Floor panel flatness:	0.030" (0.76 mm) in any direction.
Floor panel width or length from specified size:	+/- 0.010" (0.25 mm)
Floor panel square ness:	+/- 0.015" (0.38 mm)

13.13 EXECUTION**13.13.1 EXAMINATION**

Examine structural sub floor for unevenness, irregularities and dampness that would affect the quality and execution of the work. Do not proceed with installation until structural floor surfaces are level, clean, and dry as completed by others.

Concrete sealers, if used, shall be identified and proven to be compatible with pedestal adhesive. If other than manufacturer's recommended adhesives or sealers are used, verify that adhesive achieves bond to slab before commencing work.

Verify dimensions on contract drawings, including level of interfaces including abutting floor, ledges and doorsills.

13.13.2 INSTALLATION

Pedestal locations shall be established from approved shop drawings so that mechanical and electrical work can be installed without interfering with pedestal installation.

Installation of access floor shall be coordinated with other trades to maintain the integrity of the installed system. Traffic shall not be permitted on any floor area for 24 hours to allow the pedestal adhesive to set.

Floor system and accessories shall be installed under the supervision of the manufacturer's authorized representative and according to manufacturer's recommendations.

No dust or debris producing operations by other trades shall be allowed in areas where access floor is being installed to ensure proper bonding of pedestals to sub floor.

Access floor installer shall keep the sub floor broom clean as installation progresses.

Partially complete floors shall be braced against shifting to maintain the integrity of the installed system where required.

Additional pedestals as needed shall support panels where floor is disrupted by columns, walls, and cut-outs.

Under structure shall be aligned such that all uncut panels are interchangeable and fit snugly but do not bind when placed in alternate positions.

Finished floor shall be level, not varying more than 0.062" (1.57 mm) in 10 feet (3.04 m) or 0.125" (3.175 mm) overall.

Acceptance: General contractor shall accept floor in whole or in part prior to allowing use by other trades.

13.14 MODE OF MEASUREMENT

Mode of measurement will be in sqm. The Mode of measurement will be same as flooring as mentioned in IS-1200

13.15 RATES

The rates quoted by the Contractor to include all labour, material, wastage, Over Heads and Profits, transport, all taxes if applicable

TECHNICAL SPECIFICATIONS FOR LANDSCAPE - HARDSCAPE WORKS

CONTENTS

1.0	KERB STONE - PRECAST	3
2.0	FACTORY MADE CEMENT CONCRETE INTERLOCKING PAVER BLOCK	3
3.0	TURF PAVER.....	4
4.0	LIGHTING SCHEDULE	6

1.0 KERB STONE - PRECAST**Laying**

- Trenches shall first be made along the edge of the wearing course of the road to receive the kerb stones of cement concrete of specified grade. The bed of the trenches shall be compacted manually with steel rammers to a firm and even surface and then the stones shall be set in cement mortar of specified proportion.
- The kerb stones with top 15 cm. wide shall be laid with their length running parallel to the road edge, true in line and gradient at a distance of 30 cm. from the road edge to allow for the channel and shall project about 12.5 cm. above the latter.
- The channel stones with top 30 cm. Wide shall be laid in position in chamber with finished road surface and with sufficient slope towards the road gully chamber.
- The joints of kerb and channel stones shall be staggered and shall be not more than 10 mm. Wherever specified all joints shall be filled with mortar and pointed with mortar which shall be cured for 7 days.
- The necessary drainage openings of specified sizes shall be made through the kerb as per drawings or as directed by the Engineer-in-Charge for connecting to storm water drains.

Finishing

- Berms and road edges shall be restored and all surplus earth including rubbish etc. disposed of as directed by the Engineer-in-charge. Nothing extra shall be paid for this.

Measurements

- It shall be measured in cubic meters with Length of the finished work (for specified width and height of stone) shall be measured in running metre along the edge of the road correct to a cm.

Rate

- The rate shall include the cost of all the materials and labour involved in all the operations described above.

2.0 FACTORY MADE CEMENT CONCRETE INTERLOCKING PAVER BLOCK**Base**

- Interlocking paver block to be fixed on the bed 50 mm or specified otherwise thick of coarse sand of approved specification and filling the joints with the sand of approved type and quality or as specified and as directed by Engineer-in-charge.

Interlocking Paver Block

- Factory made precast paver block of M-30 or otherwise specified grade to be used. Paver blocks to be of approved brand and manufacturer and of approved quality. Minimum strength as prescribed by manufacturer and as per direction of Engineer-in-Charge for the grade specified to be tested

as per method mentioned in specification of subhead cement concrete of CPWD Specification 2019 Vol. I.

Measurement & Rates

- Area provided with paver block to be measured in sqm. correct upto two places of decimal. The rate includes the cost of the material, labour, tools etc. required in all the operations described above.

3.0 TURF PAVER

- Turf Paver is used primarily for the creation of grass or gravel access pathways for heavy emergency vehicles and stabilization of areas such as overflow parking, home driveways, golf buggy and equestrian dressage arenas and paths, helicopter landing pads and boat parking ramps. It also serves as a stabilizer for mild slopes and functions as an erosion control measure.
- It is a high strength plastic module designed to contain and stabilize grass or decorative gravel with the ability to withstand heavy loads imposed by emergency vehicles such as fire trucks. It replaces asphalt and concrete to create permeable surfaces that may be turfed or planted with ground cover and enable these areas to blend into the aesthetics of their surroundings.
- It consists of a network of sturdy porous cells which prevents soil compaction. It has top and bottom notches with a large open base that allow root and plant runners to spread freely for vigorous root development and promote healthy plant growth.

Advantages

- Supports heavy vehicular load
- Does not hinder root and runner growth
- Reduces erosion and soil migration
- Easily installed and removed
- Conforms to uneven surfaces
- Supports Green Building Certification

Applications

- Fire engine access lanes, Pedestrian pathways, Residential driveways, Overflow & street shoulder parking areas, Golf buggy paths & Racetrack in fields and pit areas 150 mm thick compacted bed of 20 mm nominal size stone aggregate shall be prepared by ramming and consolidation.
- 150 mm thick Jamuna sand shall be spread, rammed and consolidated including watering and finishing smooth etc. as per direction of Engineer-in-Charge. The turf paver shall then be laid on finished smooth surface.

Technical Specifications

Description	Specification
Material	Polypropylene
Dimensions	500 mm x 500 mm
Height	40 mm
Cell Size (diagonal)	70 mm
Weight	4.3 kg/m ² (Tolerance= (-) 1%)
Compressive Strength (unfilled)	150 t/m ² (Tolerance= (-) 1%)
Compressive Strength (sand filled)	3000 t/m ² (Tolerance= (-) 1%)
Service Temperature	-30 °C to 80 °C
Biological Resistance	Unaffected by moulds and algae
Chemical Resistance	Resistant to rot, oils, acids, alkalis, bitumen and naturally occurring soil chemicals

Measurements

- Length and breadth correct to a cm of Turf paver surface shall be measured and area shall be calculated in sqm correct to two places of decimal.

Rates

- The rate for Turf paver shall include the cost of all materials and labour involved in all operations described above. Nothing extra shall be paid.

4.0 LIGHTING SCHEDULE

S.NO	SYMBOL	DESCRIPTION	IMAGE	PRODUCT ID	SPECIFICATIONS
1	SL-1	Single arm Street Light		Pole: Circular Klite / ID: 6207 OR Equivalent	Height- 9m Colour: Grey / Single arm
				Luminaire: K-lite Waco maxi / ID: 4307 OR Equivalent	180W LED Colour temp: 4000k
2	SL-2	Double arm Street Light		Pole: Circular Klite / ID: 6208 OR Equivalent	Height- 9m Colour: Grey / Double arm
				Luminaire: K-lite Waco maxi / ID: 4307 OR Equivalent	180W LED (2nos) Colour temp: 4000k
3	PTL	Post Top Lantern		Pole: Square Klite quadra / ID : 4779 OR Equivalent	Height- 3m Colour: Grey
				Luminaire: K-lite Navya mini / ID: 4440 OR Equivalent	24W LED Colour temp: 4000k
4	BL	Bollard Light		K-lite Nimbus bollard / ID: 4726 OR Equivalent	Height :1m 16W LED Colour temp: 4000k
5	LFL	Landscape Focus Light		K-lite Trioscope bracket / ID: 6988 OR Equivalent	3W LED Colour temp: 4000k

TECHNICAL SPECIFICATIONS FOR LANDSCAPE – SOFTSCAPE WORKS

CONTENTS

1.1. SUPPLY OF GOOD QUALITY FINE TEXTURED RED SOIL	4
1.2. SUPPLY AND STACKING OF FYM.....	4
1.3. SUPPLY AND STACKING OF PIT SAND	4
1.4. SPREADING OF RED SOIL	5
1.5. SPREADING OF MANURE	5
1.6. MIXING OF RED SOIL, MANURE, PIT SAND	5
1.7. FILLING MIXTURE OF RED SOIL, MANURE AND PIT SAND	5
1.8. DIGGING HOLES FOR PLANTING TREES	6
1.9. EXCAVATION AND TRENCHING FOR PREPARATION OF BEDS FOR HEDGE AND SHRUBBERY	6
1.10. PLANT MATERIAL INSTALLATION PROCESS	7
1.11. TREE PLANTING	7
1.12. SHRUBS PLANTING IN PLANTERS AND BEDS	8
1.13. GRASSING	8
1.14. WATERING:	10
1.15. SPECIFICATIONS OF PLANTS	10
1.16. MAINTENANCE	11

1.0 SOFT LANDSCAPE WORK**1.1 SUPPLY OF GOOD QUALITY FINE TEXTURED RED SOIL:**

The item includes the cost of supply of fine textured Red soil suitable for planting etc. including royalty, loading, transportation, unloading, stacking at site. Red soil shall be light textured, crystalline, porous and friable and not of generally acidic or neutral but not of alkaline and should be fertile. Red soil shall be free from stones, pebbles, weeds, unwanted garbage, grass etc. Before affecting bulk supply contractor shall get the sample of Red soil approved for its quality/suitability. The Red soil shall not be unloaded unless approved by departmental representative failing which the material shall not be paid. In case of rejection of material for quality etc the contractor shall not unload the same and if done shall remove it at his own cost from the site. It shall be transported to the site in Truck/dumper with efficient arrangement to prevent spilling en route. It shall be stacked at site.

Measurements:

Length, breadth and depth of stacks shall be measured correct to cm.
The volume of the stack shall be reduced by 20% for looseness in stacking and to arrive at the net quantity for payment.

Rate:

The rate shall include the cost of supply, labour and material involved in all operations described above, including carriage up to RRCAT Indore site and levies if any.

1.2 SUPPLYING AND STACKING OF FYM:

Farm Yard Manure (FYM) shall be well decayed and made up of cattle /buffalo dung only. In no case the manure made up of camel/horse/sheep dung shall be accepted. FYM shall be free from soil clods, fresh dung, unwanted garbage, grass etc. It shall be well composted, dried, well screened good quality cow dung manure in powdered form. Before affecting bulk supply contractor shall get the sample of FYM approved for its quality/moisture content. The FYM shall not be unloaded unless approved by departmental representative failing which the material shall not be paid. In case of rejection of material for quality etc the contractor shall not unload the same and if done shall remove it at his own cost from the site. It shall be transported to the site in Truck with efficient arrangement to prevent spilling en-route. It shall be stacked at site. Each stack shall not be less than 50cm height and volume not less than 3 cum.

Measurements:

Length, breadth and depth of stacks shall be measured correct to a cm. The volume of the stack shall be reduced by 8% for looseness in stacking and to arrive at the net quantity for payment.

Rate:

The rate shall include the cost of supply, labour and material involved in all operations described above, including carriage up to site and levies if any.

1.3 SUPPLYING AND STACKING OF PIT SAND:

Sand shall be naturally occurring sand, clean and free from dust organic and foreign matter and its grading shall be within the limits of grading zone IV or V. It shall be well graded down from 5mm. Depth of filling shall be the consolidated depth. The dimensions of filling shall be on the basis of pre-measurement correct to the nearest cm and cubical content worked out in cubic metres correct to two places of decimal.

Measurements:

The length, breadth and depth of consolidated sand shall be measured with steel tape correct to the nearest cm and cubical contents worked out in cubic metres correct to two places of decimal.

Rate:

The rate includes the cost of all materials, equipment, labour, carting, loading & unloading, removal of debris to local specified within the site, involved in all the operations described above.

1.4 SPREADING OF RED SOIL

Red soil shall be removed from stacks by head load and spread evenly over the surface to the thickness ordered by the Engineer-in-charge. It shall be spread with a twisting motion to avoid segregation and to ensure that spreading is uniform over the entire area.

Measurements: The quantity of red soil spread shall be determined by the difference in the volume of red soil in stacks before and after spreading duly reduced for looseness in stacking by 20% of red soil.

Rate: The rate shall include of all the labour and material involved in all the operations described above, but does not include the cost of the good earth which shall be paid for separately unless specifically described in the item.

1.5 SPREADING OF MANURE

Red soil shall be thoroughly mixed with manure in specified proportion as described in the item or as directed by the Engineer-in-Charge. The mixing shall be spread to the thickness ordered by the Engineer-in-Charge.

Measurements

The quantity of red soil and manure mixed shall be determined by the difference in the volume of red soil and manure in stack, before and after spreading duly accounted for voids and looseness in stack.

Rate

The rate shall include of all the labour and material involved in all the operations described above, but does not include the cost of red soil and which shall be paid for separately, unless otherwise described in the item.

1.6 MIXING OF RED SOIL, MANURE AND PIT SAND

Red soil, manure and pit sand shall be thoroughly mixed in specified proportion as described in the item or as directed by the Engineer-in-charge.

Measurements

- The quantity of Red soil, manure and pit sand mixed shall be determined by the difference in the volume of Red soil, manure and pit sand in stack, before and after spreading duly accounted for voids and looseness in stack.

Rate

- The rate shall include the cost of all labour and materials involved in all the operations described above but does not include the cost of Red soil, manure and pit sand which shall be paid for separately, unless otherwise described in the item.

1.7 FILLING MIXTURE OF RED SOIL, MANURE AND PIT SAND

- The separately specified Red soil, manure and pit sand shall be broken down to particles of size not exceeding 6 mm in any directions before mixing. Red soil, manure and pit sand shall be thoroughly mixed in specified proportions as directed by the PMC / Employer. During the process of preparing the mixture as above, trenches shall be flooded with water and levelled.

Measurements

- Measurement shall be made in (Length, breadth, and height of stacks) cubic meter. The cubical contents shall be worked out to the nearest two places of decimal in cubic meter.

Rate

- The rate shall include the cost of all the labour and material involved in all the operations described above, but do not include the Red soil, manure and pit sand which will be paid separately

1.8 DIGGING HOLES FOR PLANTING TREES

- In ordinary soil, including refilling earth after mixing with oil cake, manure and watering.
- Holes of circular shape in ordinary soil shall be excavated to the dimensions described in the items and excavate soil broken to clods of size not exceeding 75 mm in any direction, shall be stacked outside the hole, stones, brick bats, unsuitable earth and other rubbish, all roots and other undesirable growth met with during excavation shall be separated out and unserviceable material removed from the size as directed.
- Useful material, if any, shall be stacked properly and separately. Good earth in quantities as required to replace such discarded stuff shall be brought and stacked at site by the contractor which shall be paid for separately.
- The tree holes shall be manured with powdered Neam/castor oil cake at the specified rate along with farm yard manure over sludge shall be uniformly mixed particle not be exceeded 6 mm in any direction) in the specified proportion, the mixture shall be filled in to the hole up to the level of adjoining ground and then profusely watered and enable the soil to subside the refilled soil shall then be dressed evenly with its surface about 50 to 75 mm below the adjoining ground level or as directed by the Engineer-in-charge.

Measurements

- Holes shall be enumerated.

Rate

- The rate shall include the cost of all the labour and material involved in all the operations described above, excluding the cost of supply and stacking the requisite quantity of manure/sludge and oil cake.

1.9 EXCAVATION AND TRENCHING FOR PREPARATION OF BEDS FOR HEDGE AND SHRUBBERY

- Beds for hedges and shrubbery shall be prepared in the following manner. The beds shall first be excavated to the depth specified.
- The surface of the excavated bed shall then be trenched to a further depth of 30cm, in order to loosen the soil, and refilled. No flooding will be done at this stage, but the top surface shall be rough dressed and levelled.
- The mixed red soil, farm yard manure and pit sand shall be refilled over the trenched bed, levelled neatly and profusely flooded so that the water reaches even the bottom most layers of the trenched depth of the bed.
- The surface after full subsidence shall again be refilled with red soil, farm yard manure and pit sand mixture, watered and allowed to settle and finally fine dressed to the level of 50 mm to 75 mm below the adjoining ground or as directed by the Engineer-in-Charge.
- Surplus earth if any, shall be disposed off as directed by the Engineer-in-charge. Any surplus earth if removed beyond initially lead shall be paid separately.
- Stones, bricks bats and other foreign matter if met with during excavation or trenching shall be removed and stacked within initially lead & lift, such material as is declared unserviceable by the Engineer-in-charge shall be disposed by spreading and levelling at places ordered by him. If disposed outside the initial lead & lift, then the transport for the extra leads will be paid for separately. If a large proportion of material unsuitable for the hedging and shrubbery operations is met with and earth from outsides is required to be brought in for mixing with manure and filling, the supply and stacking of such earth will be paid for separately.

Measurements

Length, breadth and depth of the pit excavated and trenched shall be measured correct to a cm. The cubical contents shall be calculated in cubic meter correct to two places of decimal.

Rate

The rate shall include the cost of all the labour and material involved in all the operations described above. The rate shall not include the cost of supply & stacking of the manure unless the same is specifically included in the description of the item.

1.10 MATERIAL INSTALLATION PROCESS

- The Contractor shall be responsible for all the plant material during planting process and shall avoid damage to plant material.
- The Contractor shall commence the planting process as early as possible from the time of arrival of the plant material in order to avoid damages, both natural and accidental to the same.
- Prior to planting the location of trees in the pit, shrub and ground cover bed shall be marked with stakes at the site by the Contractor and after the approval of the Consulting Landscape Architect the Contractor shall plant the plant material.

- The backfilling shall be done with garden soil mix and excavated earth shall not be used. After backfilling the soil shall be levelled to the finish grade.

1.11 TREE PLANTING

Planting

- No tree pits shall be dug until final tree positions have been pegged out for approval.
- Care shall be taken that the plant sapling when planted is not buried deeper than in the nursery or in the pot.
- Planting should be carried out in well-watered soil. It is most important to plant trees at the original soil depth: the soil mark on the stem is an indication of this and it should be maintained on the finished level allowing for setting of the soil after planting. All plastic and other imperishable containers should be removed before planting.
- Any broken or damaged roots should be cut back to sound growth.
- The bottom of planting pit should be covered with 50mm to 75mm of soil. Bare roots should be spread evenly in the planting pit, a small mound in the centre of the pit on which the roots are placed will aid an even spread. Soil should be placed around the roots, gently snaking the tree to allow the soil particles to shift into the root system to ensure close contact with all roots and to prevent air pockets. Backfill soil should be firmed as filling proceeds layer by layer; care being taken to avoid damaging the roots. Organic material should be applied, according to soil requirements.

Backfilling

- The soil is back filled, watered thorough and gently pressed down, a day previous to planning to make sure that it may not further settle down after planting. The soil shall be pressed down firmly by treading it down, leaving a shallow depression all rounds for watering

Staking

- Newly planted trees must be held firmly although not rigidly by stacking to prevent a pocket forming around the stem and newly formed fibrous roots being broken by mechanical pulling as the tree rocks.

Tying

- Each tree should be firmly secured to the stake so as to prevent excessive movement. Abrasion must be avoided by using a buffer, rubber or Hessian, between the tree and stake. The tree should be secured at a point just below its lowest branch, and also just above ground level; normally two ties should be used for each tree. These should be adjusted or replaced to allow for growth.

Watering

- The contractor shall allow for the adequate watering in all newly planted trees and shrubs immediately after planting and he shall during the following growing season, keep the material well-watered.

- All shrubs, which are supplied pot grown, shall be soaked prior to planting. Watering in and subsequent frequent watering of summer planted container growth plants is essential.

1.12 SHRUBS PLANTING IN PLANTERS AND BEDS

- All area to be planted with shrubs shall be trenched to a depth of 1'-0". Tall shrubs may need staking, which shall be provided if approved by the landscape Architect, depending upon the conditions of individual plant specimen shrubs and ground cover shrubs in beds and planters.
- Positions of shrubs to be planted shall be marked out in accordance with the planning plan.
- Shrubs are set out; precautions should be taken to prevent roots drying. Poly-ethene and other non-perishable containers should be removed, and any badly damaged roots carefully pruned.
- The shrubs should then be set in holes so that the soil level, after settlement, will be backfilled to half its depth and firmed by treading.
- The remainder of the soil can then be returned and again filled by treading.

1.13 GRASSING

Preparation

- During period prior to planting, the ground shall be maintained free from weeds.
- Grading and final levelling of the lawn shall be completed at least one week prior to the actual planting. Regular watering shall be continued until sowing by dividing the lawn area into portion of approximately 5 mts square by constructing small bunds to retain water.
- These 'bunds' shall be levelled just prior to sowing of grass plants. At the time of actual planting of grass, it shall be ensured that the soil has completely settled.

Laying Of Grass

- Grass sheets (Grass approved by the landscape architect) shall be obtained from a grass patch, seen and approved beforehand.
- The grass sheets stock received at site shall be manually cleaned of all weeds and water sprayed over the same after keeping the stock in a place protected from the sun and dry winds.
- Grass stock received at site may be stored for a maximum of one day. In case grassing for some areas is scheduled for a later date fresh stock of grass roots shall be ordered and obtained.

Execution

- Grass sheets shall be fixed in proper row and very close to each other and cut whenever it is necessary and maintain the top level same. Grass area will only be accepted as reaching practical completion when germination has proved satisfactory and all weeds have been removed.

- Korean grass material for the turf shall be free from weeds and other foreign materials and shall be laid as carpet on the already prepared turf bed.
- Shade Grass shall be planted dibbling method in proper rows and very close to each other (max 2" c/c) and cut only whenever it is necessary and maintain the top level same. Grass areas will only be accepted as reaching practical completion when germination has proved satisfactory and all weeds have been removed.

Maintenance

- As soon as the grass is approximately an inch high, it shall be rolled with a light wooden roller in fine, dry weather and when it has grown to 2 to 3 inches above the ground, weeds must be removed and regular cutting with the scythe and rolling must be begun.
- A top dressing of well-decomposed well-broken sludge manure will help on the young grass. The scythe must continue to be used for several months until the grass is sufficiently secure in the ground to bear the mowing machine.
- It should be possible to use the inch above the normal level for the first two or three cutting. That is today the grass should be cut so that is from 1 to 2 inches in length instead of the $\frac{1}{2}$ to $\frac{3}{4}$ of an inch necessary for mature grass.
- In the absence of rain the lawn shall be watered every day, soaking the soil.
- Damage, failure or dying back of grass due to neglect of watering, especially for seeding out of normal season shall be the responsibility of the contractor.
- Any shrinkage below the specified levels or defects liability during the contract period shall be rectified at the contractor's expense.
- The contractor is to exercise care in the use of rotary cultivator and mowing machine to reduce to a minimum the hazards of flying stones and brickbats. All rotary mowing machines are to be fitted with safety guards.

Rolling

- A light roller shall be used periodically, taking care that the lawn is not too wet and sodden.

Edgings

- These shall be kept neat and must be cut regularly with the edging shears.

Fertilizing

- Organic mixture consisting of bone meal, need cake. Form bones. NPK in appropriate proportion. All mixed in soil in correct proportion. Bio-organic manure shall be supplied in 50 Kg. Sealed bags at site.
- The loading and unloading shall be included in supplier's scope. The fertilizer shall be dry and supplied in fresh stock.
- A proof of the same shall be submitted along with the supply and the concerned person at site shall carry out random check. If any defects are observed the entire lot shall be replaced at suppliers cost at site.
- A manufactures test report along with assurance of the quality should be given by the supplier along with the delivery. The certification on the same

shall be obtained from the landscape consultant by the supplier before final bill submission and usage.

- The supplier shall also give a manual for appropriate applications for better results for lawns, trees and shrubs.

Watering

- Water shall be applied daily during dry weather, watering whenever done should be through and should wet the soil at least up-to a depth of 30cm.

Weeding

- Prior to regular mowing the contractor shall carefully remove rank and unsightly weeds.

1.14 WATERING:

- All the plants shall be watered immediately after planting with adequate amount of water. The Contractor shall provide with the hoses of adequate length and other accessories required for watering.

1.15 SPECIFICATIONS OF PLANTS

All the plants (including trees, shrubs, ground covers, pot plants, creepers, lawn etc) should be as per following specification.

- The plants should be full of fresh and healthy foliage.
- The plants should be free from insect, pest and diseases.
- Plant should be well developed and healthy.
- The height of the plants will be measured from top of the pots.
- The plants should be well settled and should not be newly shifted/ Transplanted.
- The plants should be true to the variety and Variety name should be tagged.
- Moss stick used should be made on plastic pipe.
- Moss stick should be straight and properly fixed in the pot.
- The rejected plants materials should be removed from the site immediately.
- Moss stick should be covered with the plants in case of plants supplied with moss stick.
- The Plant should be well established and should have good foliage.
- Good earth and manure used for filling the pot/poly bag should be free from any inert material and mixed to proper ratio.
- Pot/ Poly bag used for filling the plants should be of proper size.
- There should be proper drainage in pots for plants.

- The flowering plants should also have proper flowering and should be true to the variety.
- All plant should have the tendency of growth and should not be stunted or de-shaped.
- There should be no stagnation of water in the pots.
- Plant should not have any physiological disorder.
- Tips of the Plants should have intact, there should not be any damages etc.
- In case of flowering pots flower should be on bud stage/semi bloom stage.
- In case of potted plant pots should have uniformity/same size and quality.
- Plants of bigger height should be properly supported/stacked by bamboo stick.
- Pots/Poly-bags soil should not be infectious, and plant should have free from all kinds of diseases.
- Bulbs, seeds, seedling, suckers should properly treat with fungicides before supply.

1.16 MAINTENANCE

Replacement Of Plant Material

- During the maintenance period, the Contractor shall replace plant material that die due to disease, defective growth, unsightly in appearance with plant materials of the same species with same height and size as that of the other plant material at the site in that species.
- During the maintenance period, the Contractor shall replace the lawn, ground cover that has not established uniformly.

Protection

- The Contractor shall protect planting areas from any damage due to through fare by erecting barricades.

Watering

- Copious watering shall be done every day to all seedlings.
- Hoeing and Top Dressing
- Loosening the topsoil shall be done whenever necessary up to a depth of 5-7.5cms with a hoe and enriching it by applying specified organic manures and fertilizers once in three months.

Weed Eradicating

- Hand weeding shall be done to remove the weeds along with the roots in the Planting areas regularly.

Pest Control

- Spraying suitable and specified pesticides and fungicides whenever necessary to control pests.
- Pruning and Shaping
- Pruning the dead branches, twigs and foliage from the trees and giving them a clean appearance.

TECHNICAL SPECIFICATIONS FOR FAÇADE WORKS

INDEX TABLE

S No	Contents	Page No
1	SCOPE OF WORKS	1
2	STANDARDS	4
3	DESIGN / PERFORMANCE REQUIREMENT	11
4	MATERIALS & FINISHES	21
5	QUALITY ASSURANCE	53
6	PERFORMANCE TESTING	55
7	SUBMITTALS	62
8	SAMPLES	68
9	FABRICATION	69
10	PRODUCT HANDLING & STORAGE	69
11	INSPECTION	70
12	INSTALLATION	70
13	PROTECTION	74
14	CLEANING & MAINTENANCE	75
15	GUARANTEE	75
16	PROFORMA FOR GUARANTEE	76
17	SPARES (ATTIC STOCK)	76
18	MODE OF MEASUREMENT	77
19	RESPONSE TIME	77
20	SAFETY	77
21	ITEMS TO BE CO-ORDINATED	78
22	DRAFT GUARANTEE AND INDEMNIFICATION	79
23	PREAMBLE TO BILL OF QUANTITIES	80
24	ANNEXURE 01 - FORMAT FOR DRGS & CALCULATION TO BE SUBMITTED BY FAÇADE BIDDER	85
25	ANNEXURE 02A - SPECIFICATION FOR LAMINATED GLASS	86
26	ANNEXURE 02B - SPECIFICATION FOR SGU	88
27	ANNEXURE 02C - SPECIFICATION FOR LAMINATED GLASS	88
28	ANNEXURE 02D - SPECIFICATION FOR SGU TOUGHENED / TEMPERED GLASS	90
29	ANNEXURE 03 - DGU PERFORMANCE PARAMETERS	90
30	ANNEXURE 04 - LIST OF MOCK-UPS & TESTS	91

1.0 SCOPE OF WORKS:

The scope of work includes complete design, engineering, fabrication, supply, installation including testing of materials & performance, quality control, transport, storage, protection, final cleaning & handover, guaranties & maintenance up to the defect liability period for all façade products

- Proposed system drawing details for façade elements along with the engineering calculations in line with the tender drawings and specification requirement
- Proper site survey report prior to grid module finalization and shop drawing preparation
- Shop drawings, Engineering calculations, Structural STAAD, FEM analysis for all products and components to the satisfaction of the approving authority
- QA / QC procedures & installation methodology
- Detailed project schedule
- All material approval plans & design submission plan
- Level instruments by qualified surveyor
- Anchor bolts pull out test at site before starting of bracket fixation
- All Aluminum trims & flashing covers to inside and outside of the building to seal the façade and the building structure
- All anchor bolts, fasteners and structural washers
- Aluminum alloy brackets with serrations and serrated washers in chromate finish or MS Hot Dip Galvanized brackets
- Glazing materials, EPDM gaskets, setting blocks, backer rod, sealants, spacer tapes, and related other materials
- All metal separators in nylon and GI shims
- Protection tapes of 70-80 microns for glass, Solid Aluminum till hand over stage
- All access equipment including gondolas, floor cranes, scaffoldings, hoisting and staging
- All material testing and processing test reports
- Material certification for Green Building rating
- Performance mock-up tests at laboratory condition and onsite tests (As per Annexure No: 03)
- On site visual mockups for architectural approval (As per Annexure No: 03)
- Completion of snag list to the satisfaction of engineer in charge or representative
- Complete water wash and clean one time the façade before final hand over
- As built drawings
- All process test reports, material test certificates and product guaranties and warranties
- Operation and maintenance manuals
- Design and performance guaranties
- Thermal performance calculation on overall Facade as per ECBC norms

1.1 Defined Terms

- The term 'shall' is used to denote a mandatory requirement.
- The term 'should' is used to denote a desirable requirement which is not mandatory.

- The term 'will' is used to denote information given for guidance only.
- The terms 'Accepted' and 'Acceptance' are used to denote acceptance by the PMC/Employer under the contract of the Contractor's submission.
- The terms 'Endorsed' and 'Endorsement' are used to denote Endorsement by the PMC/Employer under the Main Contract of the Contractor's submission.
- The term "Contractor" is used to denote the contractor under this contract who provides the all-facade related works which deemed to be part of the design and build contract

2.0 STANDARDS:

All Design, Material and Workmanship shall comply with the following minimum standards:

2.1 GENERAL

- NBC 2016: National Building Code of India (Bureau of Indian Standards)
- IS 875 (Part 1): Code of Practice for Design Loads (other than Earthquake) for buildings & Structures – Dead Loads
- IS 875 (Part 2): Code of Practice for Design Loads (other than Earthquake) for buildings & Structures – Imposed Loads
- IS 875 (Part 3): Code of Practice for Design Loads (other than Earthquake) for buildings & Structures – Wind Loads
- IS 875 (Part 5): Code of Practice for Design Loads (other than Earthquake) for buildings & Structures – Special Loads & Load combinations.
- IS 1893 (Part 1): Criteria for Earthquake Resistant Design of Structures
 - IS 2016: Specification for Plain washers
 - IS 3139: Dimensions for screw threads for bolts & nuts
 - IS 3757: Specification of High Strength Structural Bolts
 - IS 4000: High Strength Bolts in Steel Structures – Code of Practice
 - IS 6610: Specification for Heavy Washers for Steel Structures
 - IS 3139: Dimensions for screw threads for bolts and nuts (range M42 to M150) [covered in IS 4218: Part 5]
 - IS 2016: Specification of Plain Washers
 - IS 4000: Code of practice for high strength bolts in steel structures
 - IS 6610: Specification for Heavy Washers for Steel Structures
 - BS 6399: Code of practice for dead and imposed loads
 - BS 4190: ISO Metric Black Hexagon Bolts, Screws and Nut specification
 - BS 6105: Specification for Corrosion-resistant Stainless-Steel Fasteners
 - BS 5750: Quality Systems
 - CWCT (Centre for Window & Cladding Technology) Guidelines for Thermal Insulation, Vapour control Layer & Fabrication
 - ADCA: Aluminum Standards and Data-Wrought Products

2.2 ALUMINUM

- IS 8147: Code of Practice for Use of Aluminum Alloys in structures

- BS EN 12020: Part 2 – Tolerance on dimensions & form
- Aluminum & Aluminum alloys – Extruded Precision profiles in Alloys 6061& 6063 T5/T6
- BS EN 12373-1: Specification for Anodized Aluminum
- BS 1474: Specification for Wrought Aluminum & Aluminum Alloys for general Engineering Purposes: Bars, Extruded Round Tubes & sections.
- BS 3019: Specification for TIG welding of Aluminium, Magnesium, and their alloys
- BS 3571: Specification for MIG welding of Aluminium & Aluminium Alloys
- BS 8118: Structural use of aluminum. Code of practice for design
- BS 1470: Specification for wrought Aluminium and Aluminium alloys for general engineering purposes: plate, sheet and strip
- BS EN 485: Aluminium and Aluminium alloys. Sheet, strip, and plate. Mechanical properties
- BS EN 515: Aluminium and Aluminium alloys. Wrought products. Temper designations.
- BS EN 573: Aluminium and Aluminium alloys. Chemical composition and form of wrought products. Chemical composition and form of product
- AS/NZS 1664: Aluminum Structure code
- NBC – 2016 – Volume I – Part 6 – Section -8 – Clause 6.3.6

2.3 FINISH

- AAMA 2604: Voluntary Specification, Performance requirements and test procedures for High Performance Organic coatings on Aluminum Extrusions & Panels
- AAMA 2605: Voluntary Specification, Performance requirements and test procedures for Superior Performing Organic coatings on Aluminum Extrusions & Panels
- BS 3987: Specification for anodic oxidation coatings on wrought aluminum for external architectural applications
- BS 1615: Specification for anodic oxidation coatings on Aluminum& its Alloys
- BS 6161: Methods of test for anodic oxidation coatings on aluminum and its alloys.
- BS 4842: Specification for liquid organic coatings for application to Aluminum alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminum alloy extrusions, sheet and preformed sections coated with liquid organic coatings.
- BS 6496: Specification for powder organic coatings for application and stoving to aluminum alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminum alloy extrusions, sheet and preformed sections coated with powder organic coatings
- BS 6497: Specification for powder organic coatings for application and stoving to hot-dip galvanized hot-rolled steel sections and preformed steel sheet for windows and associated external architectural purposes, and for the finish on galvanized steel sections and preformed sheet coated with powder organic coating.

- BS 2569: Specifications for Sprayed Metal Coatings
- BSEN 22063: Metallic and Other Inorganic Coatings. Thermal Spraying. Zinc, Aluminum and Other Alloys.
- BSEN 10143: Continuously Hot Dip Metal Coated Steel Sheet and Strip. Tolerances on Dimension and Shape.
- BS 4190: Specification for ISO Metric Black Hexagon Bolts, Screws and Nuts.
- BS 6338: Specifications for Chromate Conversion Coatings on Electroplated Zinc and Cadmium Coatings.
- BS 5411: Method of Test for Metallic and Related Coatings.
- BS 5493: Code of Practice for Protective Coating of Iron and Steel Structures against Corrosion
- ASTM D523: Test Method for Specular Gloss
- ASTM D4214: Test Method for Evaluating Degree of Chalking of Exterior Paint Films
- ASTM D714: Test Method for Evaluating Degree of Blistering of Paints
- ASTM D968: Test Method for Abrasion Resistance of Organic Coatings by the Falling Abrasive Tester
- ASTM D1654: Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
- ASTM D2244: Method for Instrumental Evaluation of Colour Differences of Opaque Materials
- ASTM D2247: Method for Testing Coated Metal Specimens at 100% Relative Humidity
- ASTM D3363: Test Method for Film Hardness by Pencil
- ASTM G23: Recommended Practice for Operating Light and Water-Resistant Exposure Apparatus (Carbon Arc Type) for Exposure of Non-Metallic Materials.
- BS 1706: Method for Specifying Electroplated Coatings of Zinc and Cadmium on Iron and Steel AMD 6731, May 1991 (Gr O).
- CP 3012: Code of Practice for Cleaning and Preparation of Metal Surfaces

2.4 STEEL / WELDING

- IS 800: Code of Practice for General Construction in steel
- IS 2062: Hot rolled Low, Medium and High Tensile Structural steel.
- IS 801: Code of Practice for use of Cold-Formed Light Gauge Steel Structural Members in general Building Construction.
- IS 806: Code of Practice for use of Steel Tubes in General Building Construction.
- IS 808 – 1989: Dimensions for hot rolled steel beams, columns. Channels & angle sections.
- IS 811: Specification for cold formed Light Gauge Structural Steel Sections.
- IS 816: Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel
- IS 1161: Steel Tubes for Structural Purposes - Specification

- IS 1477: Code of Practice for Painting of Ferrous Metals in Buildings & Allied Finishes
- IS 7215: Tolerances for fabrication of steel structure.
- IS 12843: Tolerance for erection of steel structure.
- ASTM A743: Stainless Steel Castings
- ASTM A744: Stainless Steel Castings
- BS 4870: Specification for approval testing of welding procedures. Specification for automatic fusion welding of metallic materials, including welding operator approval.
- BS 4871: Specification for approval testing of welders working to approved welding procedures. Fusion welding of steel
- BS EN 729-1: Quality requirements for Welding. Fusion welding of metallic materials, guidelines for selection & use
- BS 729: Specification for Hot Dip Galvanized Coatings on Iron and Steel Articles
- BS 2989: Specification for continuously hot-dip zinc coated and iron-zinc alloy coated steel of structural qualities: wide strip, sheet/plate and slit wide strip
- BS 5950: Structural use of steelwork in building. Specification for materials, fabrication and erection
- BS 1449.2: Specification of stainless & Heat-Resisting steel plate, sheet and strip
- BS EN 10029: Hot-rolled steel plates 3 mm thick or above. Tolerances on dimensions and shape
- BS 3100 Steel Castings for General Engineering Purposes
- BS 2994: Specification for Cold Rolled Steel Sections
- BS EN 288: Specification and Approval of Welding Procedures for Metallic Materials
- BS 3019: TIG Welding
- BS 3571: MIG Welding
- BS EN 287: Approval Testing of Welders for Fusion Welding
- BS 7475: Specification for Fusion Welding of Austenitic Stainless Steel
- BS 7613: Specification for Hot Rolled Quenched and Tempered Weldable Structural Steel Plates
- BS 7668: Specification for Weldable Structural Steels. Hot Finished Structural Hollow Sections in Weather Resistant Steel
- BS EN 10113: Hot-Rolled Products in Weldable Fine Grain Structural Steel
- AWS C5.4: Recommended Practices for Stud Welding

2.5 GLASS

- BS 952: Glass for Glazing. Classification
- BS EN 410: Glass in building. Determination of luminous and solar characteristics of glazing
- BS EN 572: Glass in building. Basic soda lime silicate glass products
- BS EN 1863: Glass in building. Heat strengthened soda lime silicate glass.
- BS EN 1279: Glass in Buildings

- BS 6262 (Part 4): Glazing for Buildings. Code of practice for safety related to human impacts.
- AS/NZS 1288: Glass in buildings. Selection & Installation
- BS 6262: Code of Practice for glazing for buildings
- ASTM C1036: Standard Specification of Flat Glass
- ASTM C1048-04: Standard Specification of Heat-Treated Flat Glass – Kind HS, Kind FT Coated and uncoated glass
- ASTM C1172: Standard Specification for Laminated Architectural Flat Glass
- ASTM 1300: Standard Practice for determining Load Resistance of Glass in Buildings
- ASTM C1376: Standard Specification for Pyrolytic & Vacuum Deposition Coating on Flat Glass
- BS 6206: Specification for Impact Performance Requirements for Flat Safety Glass and Safety Plastics for Use in Building
- BS 6375: Performance of Windows
- CP 153: Code of Practice for Windows and Roof-Lights (British Standard)
- NBC – 2016 – Volume I – Part 6 – Section -8 – Clause 6.3.6

2.6 GASKET

- BS 4255 -1:Rubber used in preformed gaskets for weather exclusion from buildings. Specification for non-cellular gaskets
- BS 4255 -2: Specification for Performed Rubber gaskets for weather exclusion from Buildings. Cellular gaskets
- ASTM C509: Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
- ASTM C1115: Standard Specification for Dense Elastomeric Silicone Rubber Gaskets & Accessories.

2.7 SEALANTS

- BS 6213: Selection of Construction Sealants. Guide
- BS 5889: Specification of one-part Gun Grade Silicon Based Sealants
- ASTM D412: Standard test method for vulcanized rubber & thermoplastic elastomers tension
- ASTM C 794: Standard Test Method for Adhesion in Peel of Elastomeric Joint Sealants
- ASTM D 897: Tensile testing of adhesive bonds
- ASTM C 1184: Standard Specification for Structural Silicone Sealants
- ASTM C 920: Standard Specification for Elastomeric Joint Sealants
- ASTM C 1135: Standard Test Method for Determining Tensile Adhesion Properties of Structural Sealants
- ASTM C 509: Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
- ASTM C510: Standard test method for staining & color change of single or multi component joint sealants.
- ASTM C962: Standard guide for use of elastomeric joint sealants

- ASTM D2203: Standard test method for staining of caulking compounds & sealants
- ASTM C 1087: Standard Test Method for Determining Compatibility of Liquid Applied Sealants with Accessories Used in Structural Glazing Systems
- AAMA CW 13: Structural Sealant Glazing Systems guide.
- FGMA: Sealants Manual
- TT-S-0227E: Sealing Compound Elastomeric Type, Multi-Component (US Federal Interim Specification Board).
- BS 4254: Specification for Two-Part Polysulphide Based Sealants
- BS 5215: Specification for One-Part Gun Grade Polysulphide Based Sealants

2.8 DESIGN

- BS 6399.1: Code of Practice for Dead and Imposed Loads
- BS 6399.2: Code of Practice for Wind Loads
- BS 5588: Fire Precautions in Design, Construction and Use of Building
- BS 5588 Part 3: 983 Code of Practice for Office Buildings
- BS 5750: Quality Systems
- BS 7543: Guide to the Durability of Buildings and Building Elements, Products and Components

2.9 INSTALLATION

- AS 2047: Windows in buildings – Selection & Installation
- BS 5974: Code of practice for the planning, design, setting up and use of temporary suspended access equipment
- BS 6037: Code of practice for the planning, design, installation and use of permanently installed access equipment. Suspended access equipment

2.10 STONE

- ASTM C 1528-02: Selection of Dimension Stone for Exterior use
- ASTM C 615: Standard Specification for Granite Dimension Stone
- ASTM C880: Standard Test Method for Flexural Strength of Dimension Stone
- ASTM C 1242-02a: Selection, Design, and Installation of Exterior Dimension Stone Anchors and Anchoring System.
- ASTM C 97: Test for absorption of water and Specific gravity
- ASTM C 99: Test for Modulus of Rapture.
- ASTM C170: Test method for compressive strength of stone.
- ASTM C 1201: Test method for Structural performance under uniform static air pressure diff.
- ASTM C 1352: Test method for Flexural Modulus of Elasticity of Dimension stone.
- ASTM C 1354: Test method for ultimate strength of an assembly consists of stone with mechanical anchor.

2.11 PERFORMANCE TESTING

- ASTM E283-04: Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
- ASTM E331-00 (2016): Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
- ASTM E 330/E330M-14: Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
- AAMA 501.1-17: Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure
- AAMA 501.4-18: Recommended static testing method for evaluating curtain wall & storefront systems subjected to seismic & wind induced Inter-storey drift
- AAMA 501.2: Quality assurance & Diagnostic Water leakage field check of Installed storefronts, curtain walls, and sloped glazing systems
- ASTM E 488: Standard Test methods for Strength of Anchors in concrete Elements.
- AS/NZS 4284: Testing of Building Facades
- ISO/IEC 17025:2005: General Requirements for the competence of testing and calibration laboratories
- ASTM E547: Test Method for Water Penetration of Exterior Windows, Curtain Walls and Doors by Cyclic Static Air Pressure Differential.
- In the event of an overlap between difference standards, the most stringent standard shall be considered.
- No substitution of the above codes shall be accepted unless with prior written acceptance & endorsement.

2.12 PURPOSE OF SUBCONTRACT DOCUMENTS

- The Drawings & specification enclosed with the Subcontract are indicative only and show the overall dimensions and other limiting dimensions for the building envelope and its relationship with adjoining components.
- The Contractor shall be responsible for achieving the construction of the contract works while conforming to the Specifications and obtain approvals from the Regulatory Authority.
- The Contractor shall allow for the development of the design and no variation to the contract will be allowed for any modification of his initial design which may be necessary after testing in order to satisfy the requirements of this Specification.

2.13 VERIFICATION OF DESIGN, SIZES AND QUANTITIES

- All works shown or inferred from the Specifications and Drawings are intended to be the design criteria for the contract works.
- The detailed design development of the contract works shall be submitted by the Contractor for Acceptance and Endorsement.

- The Contractor shall be responsible for taking exact measurements at site prior to fabrication and installation of the contract works. He shall verify all measurements in consultation with the PMC/Employer.
- The Contractor shall allow for any additional supports on framework where required so as to ensure the stability and capability of the installed contract works to withstand all specified loads under normal usage encountered during the service life of the works.

3.0 DESIGN / PERFORMANCE REQUIREMENT

The glazing system must be meeting following requirement.

3.1 SERVICE LIFE & DURABILITY

The design of structural components shall be based upon a 50-year design life.

The durability design life of façade, with responsible routine cleaning and maintenance is 25 years. Glazing materials, stones, glass laminated panels, IGU glazed units and paint finishes may require replacement after 25 years. The performance of the façade systems will be covered under warranty for 10 years after the end of the twelve (12) months defect liability period.

3.2 DESIGN LOADS

3.2.1 DEAD LOADS

System shall transfer their own self weight & other associated deadloads to the main building structure. Dead Loads shall be computed by summing up the total self-weight of all the elements of the building envelope incorporated in the assembly, including fixtures and accessories.

The total self-weight (un-factored) shall be used in combination with wind load and live load in the design of all members. (Kindly refer section 3.3 for Load Combinations)

3.2.2 LIVE LOADS

Shall design the building envelope systems to carry the following loads in combination with full dead and wind loads (see below for load combinations):

- a. Uniformly distributed minimum loading
 - A UDL of 0.75 kN/m² for All roofs and canopies with access not provided except for maintenance.
- b. Line Loading
 - A line loading of 0.75 kN/m acting either downward or outward on all parapets and handrails such as stairways, landings, and balconies.
 - A line loading of 1.5 kN/m acting either downward or outward on all parapets and handrails such as restaurants and bars, retail and public areas, not likely to be overcrowded.
 - A line loading of 3.0 kN/m acting either downward or outward on all parapets and handrails such as retail areas, theatres, cinemas, bars, auditoria, shopping malls, discothèques, places of worship, likely to be overcrowded.
- c. Point Loading

- A point loading of 1.5 kN on all horizontal surfaces including Windows (@ 1m from FFL), projecting features like canopies, skylights, Pergola, Trellis, etc.
 - Accidental human point load on sunshade and fins 0.75 kN most critical direction
- d. These live loading requirements do not need to be superimposed with each other.

3.2.3 WIND LOADS

The building envelope shall be designed for wind loads as per the wind tunnel report and tender BOQ. The wind load requirements therein shall be satisfied considering height effects and a basic wind speed of **as per Design Basis Report**. Furthermore, the following requirements shall serve as a minimum for this project. The Contractor may increase these values as they deem appropriate. The Contractor shall be solely responsible for determining appropriate load values. The building envelope and its anchorage shall be designed to withstand wind pressures as per the tender BOQ.

- The wind pressure is as per tender BOQ.
- Design Wind Load shall be as per tender BOQ in line with the NBC 2016 / IS 875 Part III for full height of the building. The system shall pass at 1.5 times the design pressure without any failure of components.
- Corner condition occurs from edge corner of the building to 25% of the dimension of the longest side of the building, or 25% of the dimension of the shortest side of the building, whichever is greater.
- The above cladding pressures do not take account of loading to plant areas and the like with dominant openings, canopies and other projecting features. To calculate wind loads on these areas, local pressure factors according to BS 6399, and AS1170 (Part 2) shall be applied to the wind loads specified above.

3.2.4 BMU LOADS

Co-ordinate with BMU Supplier and obtain details of proposed equipment, monorails, suspension points, sockets operation live loads and directions of action. Install all required restraint fixings, brackets, supports and the like and allowable tolerances for the operation of the equipment.

Following maintenance loads (Gondola) to be considered as minimum compliance.

- BMU restraint point: 1.50 kN (in any direction)
- BMU impact loads: In accordance with requirements of the equipment supplier.

3.2.5 SEISMIC LOADS

The building envelope shall be designed for seismic loads in accordance with the requirements and standards as defined by the applicable Indian Standards / structural consultant's requirement

The loading due to earthquake is assessed based on the provisions of IS: 1893-2002 (Part-1) (Fifth Revision)

3.2.6 OTHER LOADS

Design the building envelope for additional loads applied to it, as follows:

- Design Load Reduction for Cladding to Features, Canopies and Blanked-off Walls: Single sealed panel systems to drained cavities with solid backup walls shall not be designed to incorporate wind load reduction principles based on (partial) pressure equalization.
- Temporary and Construction Loads: Design the building envelope systems to allow for all handling and installation loads without causing overstress, permanent deflection, or warping. No permanent deforming of panels, channel legs and the like during installation to enable panels to fit into place will be accepted.
- The Contractor shall design all components of the building envelope system, including supporting structural steel frame work, anchorage, fixings, adhesives and structural adhesives, to carry all temporary and permanent design loads, individually and in combination without causing failure, including failure which may be due to one or more over-stresses, including cracking, bowing, distortion and looseness, lack of rigidity, dislodgement by wind or seismic forces, excessive deflection or defects which would cause damage to adjacent or applied work by others.
- Prepare and submit full structural analysis in the form of computations and shop drawings. The Contractor shall co-ordinate with the PMC/Employer as required to obtain additional information on base structure conditions. Materials and components shall be engineered to accommodate all loading conditions.
- Strength, stiffness and sizes of components and fixings shall be adequate for all conditions and requirements.
- Design supporting corbels, brackets and cast-in anchors to carry 2 times the self-weight without causing overstress or slipping of anchors.

3.3 LOAD COMBINATIONS

Design building envelope supporting structural steel framework, brackets and cast-in anchors to carry the applied loads without causing overstress or slipping of anchors. The total self-weight shall be used in combination with wind load and live load in the design of all members, as follows:

- $(1.5 \times \text{Dead Load}) + (1.5 \times \text{Wind Load})$ for brackets, embeds and anchors.
- $(1.0 \times \text{Dead Load}) + (1.0 \times \text{Live Load})$ for railing OR $(1.0 \times \text{Dead Load}) + (1.0 \times \text{Live Load}) + (0.25 \times \text{Wind Load})$ for railing (As per requirements)
- $(1.0 \times \text{Dead Load}) + (1.0 \times \text{Wind Load}) + (100\% \text{ to } 75\% \text{ of Wind load in lateral direction})$ for vertical elements exposed to lateral load (louvers, fins etc.)
- $(1.0 \times \text{Dead Load}) + (1.0 \times \text{Wind Load})$ for all other Aluminum elements other than mentioned above.

- $(1.2 \times \text{Dead Load}) + (1.2 \times \text{Live Load}) + (1.2 \times \text{Wind Load})$ for MS structures.

These load cases are in addition to load cases specified in the relevant design codes.

3.4 LOAD SHARING

- Where two sections of different materials are used together as assembly, submit full load sharing computations based on the relative stiffness of each section.
- Composite Sections: Generally, use of composite sections shall not be allowed. However, in situations where composite sections are required and Accepted by the PMC/Employer, the Contractor shall submit full computations based on applied loads, as well as thermal expansion induced stresses. In assessing stresses in the composite sections, particular care shall be applied in determining end conditions.

3.5 ALLOWABLE DEFLECTION LIMITS

General Requirement

Any façade system that shall be serviceable under the loads shall not deflect beyond the following serviceability limits. Design wind pressure or live load to be used for deflection check.

The following are the allowable serviceability deflection limits.

a. DEFLECTION AT THE CENTRE OF THE GLASS

- Monolithic glass under Wind Load: Shorter span/60 or 19mm max (whichever is the least)
- Double glazed unit glass under Wind Load: Shorter span/90 or 19mm max (whichever is the least)
- Deflection at edge of the glass: Shall be limited to 15 mm.
- Cantilever laminated glass under wind load and live load: Cantilever span/65 or 25mm max (whichever is the least)

b. MAXIMUM ALLOWABLE DEFLECTION OF ALUMINUM FRAMING MEMBERS

- For Mullion Interlock:
 - For spans up to 4110 mm: Span/175 or 19 mm, whichever is the least.
 - For spans above 4110 mm: $(\text{Span}/240) + 6.35 \text{ mm}$, whichever is the least.
- For Transom:
 - For Wind Load: Span/175 or 19 mm, whichever is the least.
 - For Dead Load: Span/500 or 3 mm, whichever is the least.
- For Aluminum Louvers: Span/175 (Structural frames and stiffening rib members)

c. MAXIMUM ALLOWABLE DEFLECTION OF STEEL MEMBERS

- For Wind Load: Span/300
- For Dead Load: Span/500 or 10 mm, whichever is the least.

3.6 ALLOWABLE STRESS LIMITS (AS PER NBC 2016)

- The allowable Design stresses in the glass shall be as follows.

Glass Type	Allowable Surface Stress (MPa)	Allowable Edge Stress (MPa)
Heat Strengthened	52.48	41.99
Toughened	75.37	60.3

- The allowable Design stresses for the Aluminum & MS members shall be as follows:
Utilization should be restricted up-to maximum 90%

3.7 THERMAL STRESSES

- Design Temperature Range: The Contractor shall design the building envelope based on a surface material temperature range from 0 to +75 degrees C. Prepare and submit full analysis of all components and/or assemblies and indicate all design movements on the shop drawings.
- Movements within Building Envelope Systems due to Thermal Loads: Provide for all thermal movement to take place freely in the plane of the building envelope systems without causing harmful buckling, failure of joint seals, undue stress on fasteners and glass or other detrimental effects. No component or system shall be stressed or subject to induced loading as a result of thermal movement. Full movement allowances including assembly and installation tolerances shall be incorporated into all junction/components at each expansion joint or assembly. Any deviation from the above stated requirements for thermal design, shall require analysis and computations which fully allow for the following issues:
 - Meteorological records indicate daily and seasonal maximum and minimum temperatures, wind, and other relevant weather effects.
 - Solar radiant heat loads and any effects of conduction and convection.
 - Shading, including shading from parts of this building and from adjacent buildings.
 - Reflection, including reflection from parts of this building and from adjacent buildings.
 - Orientation and color.
 - Resultant "service" temperature of building envelope system components.

3.8 BUILDING STRUCTURES

A. BUILDING MOVEMENTS

- Design building envelope systems to provide for deflections, displacements and other movements within the building envelope system, and between the building envelope system and the base building (including fire stop and smoke flashing connections). Include movements caused by ambient temperature changes, wind loads, dead loads, live loads, seismic loads and

shrinkage. The Contractor's design shall include moveable joints to accommodate the full range of movement requirements including manufacturing tolerances, site tolerances, thermal movement, lateral movement, floor sag, beam sag, live load deflection and column settlement.

- Allowance for movement shall be in addition to allowance for building tolerances.
- Joints shall accommodate the worst possible combination of effects to prevent loads of any kind being transferred from the building into the building envelope system, excessive movements of any joints or failure of weather seals.
- Prepare and submit full analysis and complete details of proposed design movement allowances based on the base structure information contained in the Specifications.
- Indicate movement limits and required clearances on shop drawings.
- Accommodate movements within the design movement allowances indicated on the Accepted shop drawings, silently and without failure of the system, permanent deformation, reduction of performance, visible movement at any joint, or other detrimental effects including:
 - Application of stresses or induced loads to any component or system, including structural elements, fixings, glass or face panels.
 - Damage to any component or system, including structural elements, fixings, glass or face panels.
 - Failure of joint seals.
- Design movement joint and select sealant products to accommodate all required expansion and contraction within joint tolerances indicated on the Accepted shop drawings and within the sealant movement limits recommended by the sealant manufacturer under loaded and unloaded conditions.
- All movement allowances shall be consistent and applied across all junctions and/or components for each expansion joint system or assembly.
- The contractor shall regularly assess and take into consideration the effect of ongoing base building movements on the building envelope set out.

B. BASE BUILDING MOVEMENTS DUE TO LATERAL DISPLACEMENT OF BUILDINGS:

- Design building envelope system so that no structural element, joint or weather seal failure occurs for lateral movements between successive floors. Allow for a minimum of +/-8mm of horizontal racking for each 4m of height.

C. LONG-TERM BUILDING MOVEMENTS

- The base structure will continue to undergo displacement during the life of the building due to variation in live load and creep of the concrete structural elements.
- Design the building envelope system to accommodate the absolute relative vertical deflections and horizontal movements that may occur due to panel

rotations due to the following displacements occurring between successive floors:

- Differential column and core shortening.
- Beam or slab edge displacement.
- Axial Shortening of edge beams.
- Floor-to-floor drift of the building.
- Make allowance for long term axial shortening of edge beams: 0.4 mm per 1-meter length.
- Make allowance generally for differential live load deflection of edge beams or slabs: +/- 16mm.

D. Movement Joint between Floors: The Unitized / Semi-unitized Curtain wall is designed to accommodate differential floor movements and thermal expansion without inducing any stresses in the curtain wall system or creating any noise. This is to be achieved by either providing a stack joint at the sill, or by providing sliding joints and flexible seals to the cassette frames and back pans at the split mullion.

E. BASE BUILDING TOLERANCES

- The building envelope shall be designed to accommodate the primary structure construction tolerances.
- Unless otherwise noted elsewhere, the maximum construction tolerances shall be taken as follows:
 - Plan position of the building edge: +/- 30 mm
 - Level of slab surface and slab soffit: +/- 30 mm
 - Deviation in plan over 20M height < 50 mm

F. FABRICATION TOLERANCES

- Tolerances at joints and junction details shall take precedence over tolerances of panels and major components.
- Tolerances generally shall be:
 - Joint width: +/- 1 mm.
 - Length and width of major components: +/- 0.5 mm.
 - Diagonals of major components: +/- 1 mm.
 - Aluminum extrusions generally: 50% ADCA standards.
 - Misalignment of mating surfaces: +/- 0.5 mm.
- Submit a schedule of fabrication tolerances for all major building envelope systems components.
- Indicate extremes of allowable base building tolerances on shop drawings.
- Aluminum tolerances regarding thickness, straightness, twisting and flatness generally exceed 50% of ADCA Aluminum Standards and Data-Wrought Products.
- Aluminum sheets for cladding panels shall be tension leveled.
- Flatness of PMC/Employer stainless steel shall be not less than "stretcher level" graded. Submit manufacturer's specifications for review and Acceptance.

G. INSTALLATION TOLERANCES

In addition to required fabrication tolerances, all parts of the building envelope for the contract works, when completed, shall be within the following tolerances:

- Position on plan, or vertical surface: +/- 1 mm.
- Deviation in alignment: +/- 3mm in one storey height
- Deviation in level (horizontal): +/- 3mm in one storey height
- Deviation in plumb (vertical): +/- 2mm in one storey height
- Offset in alignment of adjoining surfaces: +/- 0.5 mm.
- Offset in alignment of separated surfaces: +/- 1.5 mm.
- Bracket fixing tolerance: Not more than 1mm.
- The Contractor shall check at site the cumulative effect of all building tolerances and adjust installation procedures as required.

H. IDENTIFICATION OF CLADDING AND GLAZING PANELS

- The Contractor shall provide a complete numbering system and schedule for all cladding and glazing panel units. Each panel shall be individually numbered in such a way that the manufactured history can be traced. Provide a permanent concealed marking system. Submit details for review and Acceptance.
- Identify the location of each individual panel on shop drawings and as-built drawings.
- Before the panels are delivered to the Site, provide suitable marks or identification for each panel to show its correct location and orientation when installed.
- Identification labels on glass shall be made on a non-marking adhesive tape fixed to the glass. No tape shall be put onto the reflective coating side of a glass panel.

I. DIMENSIONAL STABILITY

- All work carried out by the Contractor shall have adequate dimensional stability to function properly and prevent damage to adjacent or applied work by other contractors.
- Design shall allow for the following:
 - Expansion and contraction
 - Building movement
 - Dimensional changes due to weather change

J. VISUAL REQUIREMENTS

- Profiles: The Contractor shall design building envelope components so that sizes, profiles, dimensions and style satisfy the Performance Specifications. The Drawings included in the contract are to be used as a guideline. Indicate variations on the shop drawings. The Contractor shall not commence production of extruded aluminum sections until all profiles have been Accepted and Endorsed.

- **Applied finishes:** The design of the components, selection and application of finishes, and installation procedures shall ensure a high standard of applied finish protection during construction. The Contractor shall develop and implement procedures to eliminate scratches, marks and blemishes to finished surfaces during constructions. Indicate procedures in the installation procedures.
- **Flatness and alignment:** The design of the components, fabrication and installation procedures shall ensure a high standard of flatness, joint and edge straightness, and alignment of mating surfaces of joinery. Close attention shall be given to cutting and cut-edge treatment procedures, stiffening and the tightening of fixings and fastenings which may cause distortion or warping.
- **Exposed sealant:** Indicate all sealants and gaskets on shop drawings. Indicate the anticipated service life and method of replacement for all sealant and gasket components. No exposed sealants of any type, structural, weather smoke or otherwise shall be permitted in any of the finished external works which will be exposed to public view unless specifically indicated in the contract Drawings or subsequent Instructions by the PMC/Employer. In the event that internal sealants are required as a remedial measure to alleviate a leaking building envelope, the Contractor shall be held liable for compromising the aesthetic integrity of the finished building envelope.

K. MAINTENANCE REQUIREMENT

- **General:** Provide design of the building envelope systems to allow for all BMU/cherry picker loads which may occur.
- **Restrain pins,** if required, shall be provided by BMU vendor to façade contractor so that facade contractor can install in the façade system.
- **Damage:** Horizontal or near horizontal surfaces, which form part of the building envelope systems such as copings, beam encasements, ledges, or the like, shall be designed to carry human live loads from maintenance personnel.
- **Self-cleaning:** The design of all components for the contract works shall be such that their configuration shall facilitate the self-cleaning of the various systems. Inclined drainage surfaces and flashings, properly designed drip grooves and self-cleaning joint design are examples of this requirement.
- **Panel replacement method:** The Contractor shall design and install the building envelope systems to allow for the future replacement of any individual panel. The Contractor shall submit details and procedures for replacing individual damaged items as part of the shop drawings.

L. ENVIRONMENTAL CONSIDERATIONS

- **General:**
Design and warrant the building envelope system to be watertight, weatherproof and have the required acoustic performance.
- **Self-Generated Noise:**

- Design and install all building envelope systems (generally and all components) to provide for noiseless movement caused by thermal expansion and when subject to dynamic loading caused by wind as well as live loads, Building Maintenance Unit (BMU) and cleaning operations.
- The system shall not generate noise due to creaking, drumming, or rattle.
- All building envelope surfaces shall not whistle due to wind.
- **Lightning:**
 - Provide electrical continuity and conductivity within the building envelope systems.
 - Include connections and provide earthing straps for connection to the building conductors by the Electrical contractor.
- **Smoke isolation and Fire Separation:**
 - Design entire system to provide smoke isolation between every floor at all levels and elsewhere as required.
 - Provide baffles fixed and sealed between base structures and building envelope systems.
 - Submit details on shop drawings for review and Acceptance.
 - Provide materials and methods of fabrication, installation and sealing which meet the statutory requirements.
 - Use materials which are non-corroding, or protected against corrosion, or of such thickness that corrosion will not impair the required fire stopping or smoke flashing function during the service life of the system.
 - The gap between the building envelope and the concrete slab edge shall be filled with an insulation material with a 2-hour fire resistant period that is accepted for use by the relevant local Authorities and Accepted by the PMC/Employer.
- **Airtightness:**
 - In addition to the requirements for a drained joint system, the design and installation of the air sealing shall be carried out to high standards (ASTM E283) to minimize air-filtration.
 - Co-ordinate with installers for adjacent work to achieve the specified maximum air filtration at junction with building envelope systems.
 - Air infiltration and exhaust limits shall be confirmed through testing.
- **Acoustic Performance:**
 - The cladding systems shall be designed to meet the external noise intrusion criteria contained in BS 8233. The Contractor shall provide the acoustic performance specified.
 - Reference shall be made to the Acoustic Specification for full details of the acoustic performance criteria.
- **Terminology and acoustic rating:**
 - Façade sound insulation refers to the sound insulation between the exterior and interior of the building.

- Horizontal flanking sound insulation refers to the situation where partitions connect to the exterior walls and sound is transmitted from one space to another via cladding.
- Vertical flanking sound insulation refers to the transmission of sound, via cladding, from one space to another above or below.
- Acoustic rating values shall be calculated in accordance with BS EN ISO 717: Part 1.
- **Test samples:**
 - The tested sample(s) shall be representative of the cladding to be installed including typical joints and all other elements that may affect the sound insulation.

4.0 MATERIALS & FINISHES:

4.1 ALUMINUM:

- Provide accepted aluminum extrusions and/or sheet of alloy and grades suitable for the structural requirements, applied finishes and project conditions not less than the strength and durability properties of the alloy and temper designated in the relevant Standards. Submit details including proposed alloy types with supporting justification data for review and Acceptance.
- All aluminum materials shall be of consistent high quality regardless of source.
- Established Manufacturers shall be accepted with a reputation for producing high quality materials with a minimum of 10 years documented continuous track record. Submit details for review and Acceptance.
- Mill finish on non-visible surfaces will not be acceptable.
- Submit manufacturer's certificate of compliance or test report for each batch of aluminum supplied.
- Each batch shall be suitably identified and cross referenced with the certificate.

4.1.1 ALUMINUM EXTRUSION

- Aluminum extrusion shall be of Alloy 6061 / 6063 T5/T6 confirming to
BS EN 573-4:1995, BS EN 573-3:1995, BS EN 755-6:1996, BS EN 755-3:1996, BS EN 755-4:1996, BS EN 755-2:1997, BS EN 755-8:1998, BS EN 755-7:1998, BS EN 12020-2:2001, BS EN 755-9:2001
- The minimum wall thickness for the structural members shall be 2.5mm & non-structural member shall be 2.5mm thk at mechanical engagement points.
- The extrusion tolerances shall confirm to BS EN 12020 In case of Aluminum structural support brackets the Alloy shall be 6005 grade & T5 temper.
- Extruded profiles shall be free from die lines, pressure marks, scratches or graphite lines.
- The Extrusions Shall have webs, walls & flanges of sufficient thickness and eliminated permanent distortion of elements in the finished works.
- Extruder shall be subject to quality review by consultants.
- All matching sections should be extruded with single extruder to avoid profiles mismatch.

- Solid Aluminum sheet shall be of Alloy 5005 H14 Series
- Solid metal panels shall be designed, fabricated & installed in such a manner that the panel should be flat when viewed from any time & any angle.
- Distortions, waviness, ripples shall not be permitted in any solid metal panels.
- **Warranty:** All the extrusions should have a back-to-back warranty of minimum 15 yrs.

4.1.2 ALUMINUM PROFILES FINISH

- Coating on the aluminum surfaces can be solid / metallic as per architect's & client's approval.
- No part of Aluminum to be left in mill finish. Different types of coatings/finishes applicable to Aluminum are as follows.

4.1.3 SUPER DURABLE POWDER COATING (External & Internal Visible Profiles)

4.1.3.1 GENERAL

- Powder coating shall be factory applied by electrostatic spray.
- The finish to confirm as per AAMA 2604.
- The coating thickness for single coat shall be 60 to 80 microns with 25 years warranty.
- Aluminum surfaces shall be pretreated in accordance with ASTM B449 under chromates Class 1 to provide maximum corrosion protection.
- Use a single supplier & applicator throughout production to ensure consistency.
- The coatings are to be free of flow lines, streaks, blisters, pin holes, tears, damage & other surface defects.
- Powders shall be of thermosetting and super durable type. It must be Lead, Cadmium and TGIC (tri-glycidyl-iso-cyanurate) free, to ensure strict environmental compliance. The powder manufacturer shall provide written confirmation on this item.

4.1.3.2 Colour and Finish

- The colour and gloss range samples shall be submitted to the PMC/Employer for Acceptance. The two (2) samples in each set shall represent both the degree of specular gloss, and the lightest and darkest shades of that colour that will be acceptable. For colour of coatings, refer to Finishes Schedule.
- Aluminum surfaces shall be pre-cleaned in accordance with the procedures recommended by the paint manufacturer. Aluminum surfaces shall be pre-treated in accordance with ASTM B 449 Class1.
- All coatings, when cured, shall be visibly free of frowziness, streaks, sags, blisters or other surface imperfections or defects.
- The Contractor shall provide a compatible air-dried coating for field touch-up as recommended by the coating manufacturer and based on, at the minimum, the standards set out in AAMA 2605 for external surfaces and AAMA 2604 for internal surfaces, to match the factory-applied finished work.
- A touch-up sample should be provided to the PMC/Employer for Acceptance, prior to the commencement of painting.

4.1.3.3 Quality Records and Testing:

Relevant standards the Contractor shall comply with:

- AAMA-2605 / 2604 :1998: Colour uniformity
- AAMA-2605 / 2604 & ASTM B244-97: Film thickness
- AAMA-2605 / 2604 & ASTM D523-89: Specular gloss at 60° viewing angle
- F-2H ASTM D523-89: Pencil hardness
- ASTM D1737-62: Post formability, 180-degree bend around 3mm mandrel
- AAMA-2605 / 2604 & ASTM D3363: Film adhesion
- ASTM D968-93: Abrasion resistance, 65min
- AAMA-2605 / 2604 -98: Chemical resistance
- AAMA-2605 / 2604 -98: Corrosion resistance
- Fed Test 6152, Fed Stds 141a: Weather thermometer 500 hv exposure
- ASTM D714-02 & ASTM D2247-02: Humidity 3000hrs exposure at 100% relative humidity
- ASTM B117-02 & ASTM D714-02: Salt spray 3000hrs in salt fog at 95°F
- ASTM E84: Flame test

In addition to the standard tests listed above, the coating shall comply with the following:

- Colour shall be in accordance with the PMC/Employer selection as per the accepted control samples.
- Powder / PVDF coatings shall be in full compliance with AAMA 2605 for external surfaces and AAMA 2604 for internal surfaces.
- Coating thickness for single coat system to be at least 60 to 100 microns and must be of super durable polyester grade.
- Coatings shall be warranted for a minimum period of 25 years & 30 years for powder coating and PVDF coating respectively.
- Powders shall be of thermosetting and super durable type. It must be Lead, Cadmium and TGIC (triglycidylisocyanurate) free, to ensure strict environmental compliance. The powder manufacturer shall provide written confirmation on this item.
- Aluminum surfaces shall be pre-treated in accordance with ASTM B 449 (Standard Specification for Chromates on Aluminum) under chromates Class 1 to provide maximum corrosion protection.
- To ensure optimum weather ability, coated panels must be initially submitted to an independent laboratory for accelerated tests for 3000 hours. QUV A tests must have at least 80 % gloss retention and colour change shall not exceed 5 delta units.
- During production, large size standard colour range samples will be used to compare production colors with the Accepted colour range samples. Upon completion of coating and prior to sealing, each production part will be inspected for comparison of colour range and overall uniformity of appearance.
- Materials shall not be shipped, delivered or supplied when the finish of such material:
 - Has not been inspected and tested in the manner and by the means described above.

- Does not meet all the specifications for the finishes set forth in all the manufacturer's instructions.
- Does not fall within the colour range Accepted by the PMC/Employer.
- Has not otherwise been processed in accordance with these specifications.
- Coatings shall be factory applied and records of samples of the entire coating production shall be maintained. The program of records shall be proposed by the Contractor for Acceptance by the PMC/Employer Records and samples shall be made available to the PMC/Employer at his request.
- Notwithstanding the Acceptance and implementation of the above-mentioned programs on samples, quality control and field touch-up air-dried coating systems, any installed work with coating defects or variation in colour or tonality in excess of the Accepted sample range will be subject to rejection by the facade PMC/Employer.
- **Warranty:** All powder coatings shall have a back-to-back warranty of minimum 25 years

4.1.3.4 CHROMATIZING: All Non-Visible Alum. Profiles

- All Nonvisible Aluminum Profiles shall have chromatizing treatment to improve resistance to corrosion.
- Comply with ASTM D 1730 Standard Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting
- The process shall be as follows:
 - Step 1: Clean - Alkaline or acid uniform mild etching, 1to 5 minutes, 140 to 180 Deg. F
 - Step 2: Rinse - Water rinse - 30 seconds - Ambient temperature
 - Step 3: Deoxidize - Acid - 1 minute - Ambient temperature.
 - Step4: Rinse - Water rinse - 45 seconds - Ambient temperature.
 - Step5: Conversion Coating - Amorphous Chrome Chromate - 45 seconds - 75 to 90°F.
 - Step 6: Rinse – Water rinse – 30 seconds – Ambient temperature.
 - Step 7: Final Rinse – Acidulated rinse or water with T.D.S Less than 300 ppm - 15 seconds - Ambient or may be heated to 150°F to facilitate drying.
- Coating weight – Coating weights of these coatings are required to be in the range of 30 to 100mg/sq.ft.
- Minimum Requirement – Coating weight should be minimum of 431 mg/m2 or 40 mg/ sq.ft.
- **Warranty:** All the finished surfaces shall have a back-to-back warranty of minimum 15 yrs.

4.1.3.5 QUALITY AND CERTIFICATION

- Submit manufacturer's certificate of compliance or test report for each batch of aluminum supplied.
- Each batch shall be suitably identified and cross-referenced with the certificate.
- Quality control measures shall ensure that materials are inspected before shipment. Where the required testing has not been done, finishes

requirements are not satisfied, does not fall within the colour range Accepted by the PMC/Employer, or has not been processed in accordance with the specification, then it shall not be shipped.

4.1.3.6 ALUMINUM WELDING

General:

- Carry out all welding, including detailing of all joints, welding procedures, appearance and quality of welds, and correction of defective work in accordance with approved samples and AS 1665 welding of aluminum structures.
- Welded parts shall be accurately fabricated to ensure proper fit. All welding equipment shall be of a suitable type and in good condition.

Weld Testing:

- If required, perform welding testing by an independent testing laboratory. Submit test results. In the event of test failure, rectify the defect and repeat the test.

Experience of Welders:

- Welding shall be done only by welders who have previously been qualified for the type of work required. Submit certification for each welder.

Procedures:

- Submit details of proposed welding procedures before commencing.
- Other than site welds indicated on Accepted shop drawings, do not weld on site. Where practical, locate site welds in positions for down hand welding.
- Do not weld:
 - Finished surfaces.
 - Adjacent to finished surfaces or glass, unless adequately protected from damage.

Finish:

- Finished welds shall be de-scaled and free of surface and internal cracks, and free of porosity.

4.2 SILICON GASKET (If required)

- All exposed weather gaskets shall be of Silicon Gasket.
- Comply with ASTM C1115: Standard Specification for Dense Elastomeric Silicone Rubber Gaskets and Accessories
- Silicone gaskets shall be Grey in color unless specifically asked for.
- All gaskets must be resistant to oxidation, Ozone & UV degradation.
- Where indicated on the Drawings or required, provide Accepted co-extruded profiles of polypropylene and polypropylene compatible products.
- **Warranty:** The gasket shall have a back-to-back warranty of minimum 15 yrs.

4.3 EPDM GASKET

- All unexposed weather gaskets shall be of EPDM microwave cured gaskets confirming BS 4255
- Shore A Hardness shall be 75 +/-5 for Solid Profiles & 60 +/-5 for Hollow Profiles confirming to ASTM D2240.

- All gaskets shall be black in color unless specified.
- All gaskets must be resistant to oxidation, Ozone & UV degradation.
- Inaccessible gaskets shall remain effective during the lifetime of the building to ensure water tightness.
- Where indicated on the drawings or required, provide dense profiles including flashings, wiper seals and the like, complying with ASTM C864, as follows:
 - Shore A durometer hardness: 75 +/- 5 for solid profiles and 60 +/- 5 for hollow profiles when tested in accordance with ASTM D2240.
 - Compression set (168 hrs.) at 70°C: Not greater than 40% when tested in accordance with ASTM D395.
- **Warranty:** The gasket shall have a back-to-back warranty of a minimum of 15 yrs.

4.4 SCREWS & FASTENERS

- All Bolts & Nuts shall be SS316.
- Screws and fasteners threading shall confirm to DIN standard or equivalent.
- Tightening Torque shall be as per manufacturer recommendation by Torque Wrench only.
- **Warranty:** The screws / fasteners shall have a back-to-back warranty of a minimum of 15 yrs.

4.5 CAST IN CHANNELS & ANCHOR BOLTS

- The cast in channel of MS hot dip galvanized form as per approved make with T bolts of grade 8.8.
- The channel shall be installed with polystyrene insets & plastic end caps.
- Channel Size (Length / Width / Thickness / No of Studs) shall be checked for the most extreme loading conditions.
- Cast in channels comprise of Channels, rivets & anchor made of cold rolled steel with hot dip galvanized of minimum 50 microns complete with polystyrene insets & plastic end cap.
- The cast-in-channels need to have European Technical Approval (ETA), i.e., with the CE mark.
- The anchor bolts shall be as per approved make SS316 as per the structural calculations.
- Anchor bolt design loads shall confirm with E 488 - Strength of anchors in concrete and masonry elements.
- **Warranty:** The channels and bolts shall have a warranty of minimum 15 yrs.

4.6 SEALANTS

4.6.1 GENERAL

- The sealants shall be as per approved make with warranty of minimum 15yrs.
- All glazing sealants shall comply with manufacturer's recommendations & relevant standards in the tender specification.
- Comply with minimum dimensional requirements for edge clearance, edge cover, front clearance, back clearance, and as required by AS 1288, GANA and sealant manufacturer.

- Relevant Standards:
 - AAMA CW 13 - Structural sealant glazing systems (A Design Guide), Aluminum Curtain Wall.
 - Dow Sil - Structural Glazing: Industry Code of Practice.
- Sealant manufacturer shall be providing testing for adhesion, compatibility & non staining.
- All structural sealants shall use design strength of 140 kPa. (Tensile Stress)
- For structural glazing applications, only trained people & experienced people shall be eligible for glazing.
- All sealants shall be compatible with substrates, materials, sealants.
- All weather sealants shall be high performance non-staining, non-bleeding sealant.
- Manufacturers standard test report & certificates shall be submitted including details of the following test.
- Adhesion testing to determine if the proposed sealants will adhere to the project specific substrates such as glass and aluminum.
- All specimens shall be tested to ASTM C794, both primed and unprimed and be subjected to water immersion.
- Seven days' immersion is required for structural glazing sealants, and one-day immersion is required for weather seals.
- Compatibility testing to determine if project specific glazing accessories, such as spacers, gaskets and setting blocks, will discolor the sealant or cause adhesion loss to the substrate.
- All specimens shall be tested to ASTM C1087, an accelerated laboratory procedure using UV light exposure from UVA 340 bulbs to determine if the proposed sealants and substrates are chemically compatible.
- Stain testing is required if porous stone is used on the project.
- All stone substrates shall be tested to ASTM C1248, a test method that describes an accelerated laboratory procedure to predict the migration of plasticizers from the sealant into porous substrates such as granite, marble, sandstone, and masonry.
- All testing shall be completed prior to the commencement of sealant application.
- No final fabrication or installation will be permitted until all sealant testing is complete.
- Where sealants are used to seal movement joints, the movement capability of sealant shall be appropriate to expected maximum deflection or movement.
- Unless otherwise accepted, sealant depth for movement joints shall not exceed half the joint width.
- Fabricator to submit the purchase receipts of all sealants from approved manufacturers.

4.6.2 FIRE RATED REQUIREMENTS

- Provide Accepted fire-rated sealant and joint fillers were indicated or required. Submit test results indicating fire rating and compliance with Regulatory

requirements. All fire rated products shall comply with the Relevant Indian Standards.

- Fire rated fillers may include elastomeric sealants and rigid dry foam fillers.
- Rigid dry foam fire rated fillers which may be accepted.
- Where dry foam fire rated fillers are proposed for wall types which also have acoustic or air infiltration requirements, provide an elastomeric cover bead.

4.6.3 COLOURED SEALANTS

- Provide colored or paintable sealants where required in accordance with Accepted samples.
- Sealants shall be resistant to staining due to dirt or pollution and shall be capable of cleaning.

4.6.4 SEALANT ACCESORIES

- Provide all required accessories recommended by sealant manufacturer, including backing rods, bond breaker tape and the like. Submit details for review and Acceptance.

4.6.5 QUALITY ASSURANCE FOR STRUCUTRAL GLAZING

- Deglazing should be used as a method of quality inspection for units which are structurally glazed.
- Deglazing is used to confirm good adhesion and proper fill of the structural joints.
- Deglazing involves completely detaching the glass from the frame.
- The structural silicone sealant should be tested for adhesion to both the glass and the frame
- The inspection should include the following:
 - Size of Structural Bite
 - Size of Structural Glue line
 - Adhesion of Silicone Sealant with glass and frame
 - Joint type/Condition of Sealant applied.
 - Appearance of the sealant/uniformity of color/bubbles, etc.
- Deglazing frequency should be performed according to the following schedule.
 - 1 unit out of the first 10 units manufactured (1/10)
 - 1 unit out of next 40 units manufactured (2/50)
 - 1 unit out of next 50 units manufactured (3/100)
 - 1 unit out of every 100 units manufactured thereafter.
- A deglaze report should be completed after each test and this should be submitted as part of the warranty application.

4.6.6 MANUFACTURER'S STANDARD TEST DATA

- Submit manufacturer's standard test reports and certificates previously performed on proposed sealants, including details of the following characteristics:
 - Chemical composition.
 - Adhesion, bond strength, cohesion or tensile strength, and elongation.

- Compatibility.
- Hardness and viscosity.
- Colour stability.
- Compression set.
- Low-temperature flexibility.
- Modulus of elasticity.
- Water absorption.
- Effects of exposure to ozone and ultraviolet light.
- Stain resistance.
- Include adhesion characteristics for all relevant surfaces including applied coatings to aluminum, glass and adjacent sealants and gaskets.
- Include statement of differences between the proposed sealants and previously tested products, if any.
- Include long-term aged performance or accelerated exposure performance for the above characteristics.

4.6.7 SITE QUALITY ASSURANCE

- For substrates which cannot be tested in a laboratory, such as concrete, a site adhesion test should be performed to joint substrates, prior to installation of the sealants at site.
- The site adhesion test can be performed on a trial joint which has been sealed at site and allowed to fully cure for a minimum of seven days.
- For all sites applied joints field adhesion testing should be performed and results of tests submitted.
- Provide documentation for site adhesion testing at the following rate.
- Adhesion testing should be performed once per floor per elevation.

4.6.8 INSTALLATION

- Install materials in accordance with the manufacturer's printed instructions, unless otherwise specified and documented.
- Clean all substrates to be sealed using the solvent recommended in the sealant manufacturer's laboratory adhesion report.
- Suitable solvents include isopropanol, MEK and xylene, but recommended solvents will depend on substrates being cleaned.
- Use masking tape or other precautions required to prevent contact of sealant or primer with adjoining surfaces which could be permanently stained or damaged by cleaning methods required to remove sealant smears.
- Remove tape immediately after tooling without disturbing sealant.
- Prime all substrates recommended by the sealant manufacturer, based upon adhesion testing.
- Primer should be applied before installation of spacer or backer rods.
- Install spacer tape for structural joints, as shown on approved drawings.
- Install backer rod for weather seal joints as recommended by the sealant manufacturer, to prevent 3-sided adhesion, which can impair the performance of the sealant.
- Do not puncture the surface of polyethylene backer rods.

- Apply sealants in continuous beads filling joint from the bottom without openings, voids or air pockets so as to provide a watertight and airtight seal for the entire joint length.
- Apply sealants in the depth shown or apply them in accordance with the manufacturer's recommendations.
- Apply elastomeric sealants, in field joints to a depth equal to half of the joint width, but not less than 6mm and not more than 12mm.
- Immediately after sealant application and prior to skinning, tool sealants form smooth, uniform beads and to ensure contact and adhesion of sealant to sides of joint.
- Remove excess sealant from surfaces adjacent to joint.
- Do not use tooling agents.
- Only trained glaziers are to be used.

4.6.9 CURE & PROTECTION

- Cure sealants in accordance with the manufacturer's instructions, to obtain maximum bond to surfaces, cohesive strength and durability at the earliest possible date.
- Protect sealants during the remainder of the construction period, so that they will not be subjected to damage before the time of acceptance by the Owner.

4.6.10 WARRANTY

- The sealants to be back-to-back warranty of minimum 10yrs.

4.6.11 LOUVERS

- Provide Accepted proprietary louver assemblies complete with all accessories and fixings, together with structural calculations for blades, frames, fixings, and blanked off sections.
- Submit drawings and details including structural and test data for review and Acceptance.
- Unless otherwise indicated on Drawings, finish shall match adjacent cladding system finish.
- Design and/or select external louver assemblies to withstand the required design wind pressure without failure or permanent distortion of members, and without blade flutter.
- Structural frames and stiffening rib members shall not deflect by an amount greater than span/240 when tested the required design wind pressure.
- Where required for access, provide framed and hinged louvered access doors to match the appearance of the adjacent louvers.
- Install louvers into frames by methods which resist unauthorized removal but can still be moved by authorized personnel.

4.7 BRACKETS, FIXINGS & ANCHORS GENERAL

- Design and provide all connections, brackets and fixings by Accepted methods so that all loads can be transferred from the building envelope

system to the base structure in accordance with the design criteria and in a manner that prevents excessive joint displacement, slippage or distortion.

- All components are to be designed for the maximum tolerance of the system, and due consideration shall be given to additional forces from prying action and bolt group effects.
- There shall be no direct fixing or close contact between any part of the building envelope system and the base structure or internal linings, except through Accepted bracket connections.
- Brackets and related components shall be scheduled and described in detail on shop drawings.
- Show details of all related components and connections to areas by others.

4.7.1 Brackets

- Brackets shall be resisting all loads, movements & dimensional changes that may occur in the building due to thermal changes, deflections, settlement & creep
- Use locknuts to prevent loosening due to movements / Vibrations.
- Brackets shall accommodate the three-dimensional building tolerance with serrations / serration washers.
- Fixings shall be corrosion resistant, and non-staining to adjacent work.
- Fixings shall be concealed unless otherwise accepted in the drawings.

4.7.2 Base Building Substrates

- Provide contingency design and installation procedures for all typical substrate conditions and deficiencies including:
 - Reinforcement clash.
 - Excessive out-of-tolerance concrete.
 - Clash with concrete joints, and other structural details.
 - Dislocated, missed and incorrect embedment.
- Check all base structure reinforcement locations. Coordinate with the PMC/Employer and refer to structural drawings to establish bracket fixing locations. Verify relationship between brackets and concrete reinforcement on shop drawings.

4.7.3 Anchors

- Provide anchors and other methods of attachment of the building envelope system to the base structure which:
- Are compatible with the bracket assembly and together provide three-way adjustment to accommodate fabrication and construction tolerances.
- Fix the building envelope system in its correct position providing for building and building envelope movements.
- Are structurally adequate to carry the design loads for the worst possible bracket positioning.
- Anchors are to be designed considering cracked concrete condition.
- All anchors shall be SS 316 grade.

- Minimum M10 anchors to be used for main heavy structures / façade systems (for light weight façade elements lower diameter anchors can be used subject to consultant's approval.)
- Anchor utilization should be restricted up-to maximum 90%
- Comply with all local Authorities requirements.

4.7.4 Fixing Brackets

- Design fixing brackets for the worst possible panel eccentricity, packing location, and uneven load sharing. Include prying effects on bolt groups.
- Design and install brackets so that all building envelope loads are transmitted through brackets and prevent transfer of loads through panel joints to adjacent panels.

4.7.5 Bolts Nuts & Washers

- SS 316 bolts, nuts and fasteners should be as per the structural calculations.
- Minimum M10 Nuts & bolts to be used for main heavy structures / façade systems (for light weight façade elements lower diameter nuts & bolts can be used subject to consultant's approval.)

4.7.6 HSFG Bolts

- High Strength Friction Grip Bolts and associated nuts and washers shall comply with BS 4395: Part 1 unless otherwise specified. Contact surfaces shall be left unpainted or prepared as otherwise indicated on the shop drawings. HSFG Bolts shall be installed in accordance with BS 4604 using a wax-based lubricant and coronet type load indicator washers or as Accepted by the PMC/Employer.

4.7.7 Holding Down Bolts

- Holding down Bolts and associated nuts and washers shall be galvanized Grade Class 4.6 to ASTM A307 or BS 4190 unless otherwise specified.
- They shall be rigidly held in place at the top and bottom by tack welding to mild steel links before galvanizing.
- They are to be located using a template that is firmly secured to the formwork or reinforcement.
- The threaded length is to be sufficient to take up all construction tolerances and is protected by taping and covering where impact damage may occur.

4.7.8 Screws / Studs

- All screws shall be stainless steel, those located outside the air seal line shall be SS 316 & located behind the air seal shall be SS304.
- Minimum #10 screws to be used for façade elements (lower diameter screws can be used subject to consultant's approval.)

4.7.9 Masonry Anchors

- All Anchors shall be installed in accordance with the manufacture's requirements.

- Facade Contractor is responsible for confirming all edge distance, spacing and embedment requirements are satisfied.
- Minimum distance from the concrete edge to the nearest part of the anchor: 100mm
- ASTM E488 - Standard test methods for strength of anchors in concrete & masonry elements
- BS 5080: Methods of test for Structural fixings in concrete & masonry
- BS 5080.1: Tensile loading
- BS 5080.2: Method for determination of resistance to loading in shear.

4.7.10 Anchorage to Superstructure:

General:

- Provide proprietary anchorage, with corrosion-resistant finish, suitable for the substrates and conditions, with holding power at least 10 x design load. The selected anchorage system shall be accepted for use by the PMC/Employer.
- Products which may be used include those manufactured by Hilti or Fischer, or equivalent as accepted by facade PMC/Employer.
- Do not use explosive shot fired devices unless accepted in writing before commencing installation.

Channel anchorage:

- Provide channel anchorage in hot-dip galvanized steel where required, complete with polystyrene insets and plastic end caps. The Anchorage system shall be accepted for use by the PMC/Employer.
- Channel length, tail size and tail locations shall satisfy the most extreme loading conditions allowed for in the structural calculations.

4.7.11 Anchorage and Bracket Installation

4.7.11.1 Anchors to install concrete substrates:

- Install mechanical and/or chemical anchors as required to support the work by Accepted methods into base-structure. Submit details of proposed methods and obtain Acceptance in writing prior to commencing installation. Comply with hole diameters, spacing, depth and minimum edge clearances indicated on accepted shop drawings.
- Be responsible for providing details for all cast-in. Check building structure setting out prior to concreting to confirm that cast-in items are correctly positioned.
- Refer to Drawings for concrete reinforcement locations, and position anchors to minimize risk of conflict with reinforcement.
- Do not install anchors into post-tensioned concrete structures, void sections of precast concrete panels, and non-conventional concrete structure, unless accepted in writing.
- Accepted methods may include drilling, pre-formed pockets, or explosive driving. Select and install anchors strictly in accordance with manufacturer's instructions.
- Relevant Standards:

- ASTM E488 - Standard test methods for strength of anchors in concrete and masonry elements.
- BS 5080 - Methods of test for structural fixings in concrete and masonry
- BS 5080.1 - Tensile loading.
- BS 5080.2 - Method for determination of resistance to loading in shear

4.7.11.2 Anchor placement tolerances:

- Install anchors to not exceed:
 - Maximum deviation from correct position: +/- 12 mm.
 - Minimum distance from the concrete edge to the nearest part of the anchor: 100 mm.

4.7.11.3 Testing of built-in anchors:

- Carry out testing of installed anchorage in accordance with ASTM E488 and a testing programme to be submitted to the PMC/Employer for review and Acceptance before commencing.
- Anchors shall be tested to demonstrate:
 - No permanent deformation of the anchor at 1.5 x the design load.
 - No failure of the anchor at 2 x the design load.
 - No failure of the structural concrete at 3 x the design load.
- Testing shall be carried out by the anchor manufacturer or at an Accepted laboratory.
- Submit full report on proposed testing procedures, including any additional test criteria proposed, substrate inspections, and the like.
- Submit test results and reports on unsuitable substrates, progressively, if found.

4.7.11.4 Testing of anchors to installed concrete soffit.

- Test anchors supporting loads suspended from concrete soffits as follows:
 - Test the first 10 anchors installed.
 - If any of the first 10 fail, re-install and re-test failed anchors and test a further 10 anchors.
 - Repeat until no anchors fail.
 - Test 1 in 40 of subsequent anchors.
 - If any subsequent anchors fail, re-install and retest, together with 5 additional tests on the previous 40 anchors.
 - Repeat until no anchors fail.

4.8 BACKER ROD

- Backer rods shall be silicone compatible, non-gassing, non-staining and non-combustible.
- They are to be compressed to limits specified by the Manufacturer and shall be in a manner which prevents them from dislodging from the rebate that is being sealed.
- Backer rods shall not inhibit movement joints from allowing the designed movement of the joint from occurring.

4.9 SETTING BLOCK

- Shall comply with BS 2571.

- Where indicated on the Drawings or required, provide Accepted setting blocks of dense material as follows:
 - Shore A durometer hardness: 85 +/- 5 when tested in accordance with ASTM D2240.
 - Compression set (168 hrs.): Not greater than 25% when tested in accordance with ASTM D395.
- Locate setting blocks at quarter points (1/4 of the unit width from each corner) unless otherwise Accepted but not less than 150 mm or 0.125 x glass width between edge of glass and edge of setting block.
- Shims used with setting blocks shall be the same material as the setting block.
- Setting blocks shall be secured against dislodgement.
- Setting Block lengths shall be calculated in accordance with BS6262 and shall be not less than 75mm.
- **Warranty:** The setting block shall have a back-to-back warranty of minimum 15 yrs.

4.10 SIDE BLOCK

- Where indicated on the Drawings or required, provide Accepted side blocks of dense material as follows:
- Shore A durometer hardness: 55 +/- 5 when tested in accordance with ASTM D2240.
- Install side block with 3 mm clearance between block and bearing surface. Block shall be of sufficient length to prevent point loading on the glass.
- Side blocks are not required where glass is supported along the vertical edges with structural silicone.
- Side blocks of extruded silicone may be accepted for IGUs with silicone edge seals. Neoprene or EPDM side blocks may be accepted only if recommended by the IGU manufacturer.

4.11 PADS

- Provide Accepted friction reducing pads to separate moving surfaces at all connections subject to thermal or other movement (Acceptable materials include Teflon or Graflon or Herculon).
- Pads shall have minimum 3 mm thickness, shall sufficiently reduce friction to permit movement, shall be resistant to wear, shall be positively retained in position (open ended slots are not acceptable).
- Pads shall not be subjected to heat damage from welding or cutting or to excessive pressure from over-tightening of bolts.
- **Warranty:** The pads shall have a back-to-back warranty of minimum 15 yrs.

4.12 FLASHING / TRIMS / FLOOR CLOSURE

- Provide all required flashings, baffles, trims, capping and the like to prevent the entry of water and weather, and make neat and clean junctions with the base-structure and adjoining work.
- Where visible, provide matching materials and finishes. Include all fixings and sealing.

- All flashings shall be cut and folded to Accepted profiles out of non-corrosive materials, with protective coatings as required.
- Flashing shall be factory fabricated in long lengths where practical, and pre-painted on visible surfaces.
- Flashing shall be of adequate stiffness to retain shape and to resist lifting by the wind.
- Make provision for differential movements and for separation of dissimilar materials.
- Continuous flashings shall be welded or mechanically fixed to form continuous uninterrupted lengths.
- Corners shall be accurately scribed and mitered. If the flashing is concealed, flashing joints shall be lapped at least 100mm and sealed.
- Where flashings are fitted to pre-formed rebates, co-ordinate cast-in grooves or reglets as required.
- Construct weepholes as required to enable the passage of moisture to the outside of the building.
- Lap and seal all flashings by Accepted methods.
- Internal & External concealed flashings shall be 1.5mm thk. GI Finish
- External exposed flashing shall be 2.5mm thk. Aluminum sheet. Coating to match with external Aluminum profiles
- Internal exposed flashing shall be 2mm thk. Aluminum sheet. Coating to match with internal aluminums profiles.
- Unless otherwise indicated on the Drawings, types and locations shall be as follows: (Material)
 - steel base grade G2, coating class ZF 100.
 - Stainless steel sheet, 0.8 mm thick, Grade 304.
 - steel base grade G2, coating class Z 275.
 - Aluminum sheet, not less than 0.4 mm or more than 1.0 mm thick, in accordance with ASTM B209, Type A3203 or D5050, containing magnesium or manganese or both, with a maximum copper content of 0.25%.
 - The neoprene strip shall be 3mm minimum thickness and shall comply with ASTM D1149 with regard to ozone and flame resistance. The materials shall have the following properties:
 - ❖ Shore hardness: 70 - 80 degrees
 - ❖ Minimum tensile strength: 13.8 MPa
 - ❖ Minimum elongation at break: 150%
 - ❖ Minimum tear strength: 1.38 MPa
 - Comply with BS 6561 - Specification for zinc alloy sheet and strip for building.
 - ASTM D1149 - Test method for rubber deterioration - Surface ozone cracking in a chamber (Flat Specimens).
- **ANTI-CARBONATION COATING:**
 - All concrete surfaces that are not protected by an air-sealed building envelope shall receive a protective finish layer.

- These surfaces are typically behind stone cladding, Aluminum rain-screen cladding and louvers.
- The surface protection shall be an anti-carbonation coating by Vandex, Sika or Accepted equivalent.
- **EARTHING TABS:**
 - The Contractor shall co-ordinate with the Electrical Contractor for details of connection tabs for earthing strap connection.
 - Earthing straps shall be provided and installed by the Electrical Services contractor.
- **TRIANGLES FOR F.A.P:**
 - Provide and install triangles for the marking of Firemen Access Panels, in accordance with local Authorities requirements.

4.13 SHIMS

- Provide shims where necessary up to but not exceeding the limits specified on the drawings and designed for engineering calculations.
- Shims which transfer shear forces shall be steel plates, set in a staggered pattern and fillet welded to each other and adjacent steel surfaces. Design shims and welds to support the applied loads.
- Polypropylene shims may be accepted at static connections where shims transfer only compressive loads.

4.14 INTERNAL WALL LININGS:

- Internal lining shall be 12mm thick cement sheet to ISO/TC77/DP8336 and ASTM C1186-2002 (with no asbestos).
- The lining shall be supported off galvanized cold formed steel battens, separated from the building envelope frame to prevent bimetallic corrosion.
- The cement sheet and batten frame shall be separated from the building envelope so that in-plane movements of the building envelope can occur without transferring loads into the cement lining.
- The building envelope can, however, be used to prevent in/out movement.

4.15 INTERNAL TRIMS TO HEADS & JAMBS:

- Internal trims shall be provided to jambs and ceiling transoms at all floors. These trims are to provide a uniform surface, with hairline joints.

4.16 HARDWARE

4.16.1 OPERABLE VENTS

- All fasteners shall be SS316.
- Facade contractors shall be submitting a technical catalogue including the test results of each hardware.
- Friction hinges in SS316 shall be self-balancing type with provision to hold open up to 150mm.
- Locking system for operable vents shall be Multi-Point Locking System or accepted equivalent.

- Locking Points shall be calculated based on acceptable vent deflection and stress limits, with a minimum of 6 (some being typhoon locks as per hardware suppliers' recommendation assuming windows are going to be subjected to PMU) locking points with top wedge blocks.
- The locking system shall be fully concealed within the body of the vent frame.
- The vents shall be manually opened to a point of full extension (minimum of 45 degree) allowing the full cross-sectional area of the vent opening to be vented.

4.16.2 DOORS / HINGES / SLIDING DOORS

- Entry door hinges shall be accepted manufacturer with concealed spring hinges.
- The hinges shall be free moving but shall be designed to a 'snug' fit to prevent any vibration of the vent in either closed or open positions.
- Revolving Doors shall be of approved vendor the type of door to be having proper air and water seals around the periphery, human detection sensors the type of door to be based on the hourly footfall.
- Door locks and handle.
- Locking mechanisms shall be of approved vendor and shall be based on a Master-Keying System.
- All fasteners shall be SS 316.

4.17 GLASS

4.17.1 STANDARDS FOR ARCHITECTURE GLASS

- ASTM C1036: Standard Specification for Flat Glass
- ASTM C1048: Standard Specification for Heat-Treated Flat Glass
- ASTM C1087 Standard test methods for determining compatibility of liquid-Applied sealants with accessories used in structural glazing systems.
- ASTM C1172: Standard Specification for Laminated Architectural Flat Glass
- ASTM C1376: Pyrolytic and Vacuum Deposition Coatings on glass
- ASTM E2190-08: Standard specification for IGU performance & Evaluation
- ASTM E546 Standard Test Method for Frost/Dew Point of Sealed Insulating Glass Units
- E2188-02: Standard test method for IGU Performance
- E2189-02: Standard test method for testing resistance to fogging in IGU
- E546-08: Standard test method for frost / Dew point of sealed IGU
- E1249-06a: Standard guide for secondary seal for sealed IGU for structural sealant glazing application.

4.17.2 SAFETY GLAZING REQUIREMENTS

- ANSI Z 97: American National Standard for Safety Glazing Material Used in Buildings –Safety Performance Specifications and Methods of Test.
- CPSC 16 CFR 1201: Safety Standard for Architectural Glazing Materials
- CCPS: Use of Glass in Buildings – Human Safety

4.17.3 INDUSTRY PUBLICATIONS:

- GANA: Glass Association of North America (formerly FGMA) Glazing Manual.
- Tempering Division: Engineering Standards Manual
- Laminating Division: Laminated Glass Design Guide
- AAMA: Curtain wall Series
- IGMA: Insulating Glass Manufacturers Alliance
- TM3000: Recommended Practices for Vertical and Basic Field Glazing of Organically Sealed Insulating Glass

- 4.17.4** The glass fabricator (and raw glass manufacturer) shall demonstrate that their internal standards and quality policies have been documented in ISO 9002 and verify continual compliance with those documents. Insulating glass units shall be an engineered product and the glass fabricator shall provide solar and optical performance data, based on LBL Window 5.2 program methodology. The insulated glass units shall meet IGBC CBA level certification.
- 4.17.5** In addition to complying with established industry standards, the glass fabricator (for all heat-treated, laminated, and insulated glass products) shall provide finished glass products which comply with the following requirements:
- 4.17.6** Optical distortion is mentioned in ASTM C 1048 Standard Specification for heat-treated glass, but the parameters for acceptability involve viewing the glass in transmission at the proper vision interference angle. To ensure the final glass products will have minimal optical distortion, the glass fabricator shall employ Quality Control procedures to ensure that distortion remains within the following allowable limits: maximum peak to valley roller wave tolerance is .003" (0.076mm) in the central area, and .008" (0.2mm) within 10.5" of the leading and trailing edge.
- 4.17.7** Additionally, note that roller wave distortion should typically run parallel to the base dimension to minimize visual perception, as viewing the reflection horizontally is usually less to run parallel to the second dimension, if the first dimension is greater than 84" (2134mm)
- 4.17.8** Insulated glass shall have double edge seals. The primary seal between Aluminum spacer and glass shall be a continuous butyl tape with no skips or voids. The preferred primary seal shall be Poly Isobutylene (PIB). The Aluminum spacer shall be of black anodized and the same shall be bent to shape of glazed unit profile and the bent Aluminum spacer shall be filled with desiccant drying agent. The secondary seal shall be Two-part silicon sealant. The secondary seal shall completely cover the spacer with no voids or gaps and shall be continuously bonded on both plates of glass. The required thickness of the secondary seal be determined by calculation and verified by testing of samples as specified.
- 4.17.9** The Glass panel shall be separated by a de-hydrated air space. Edge seal construction of the insulated unit shall be able to withstand at least three time the stress caused by design wind pressures Specified in the Bills of Quantities. The Double-glazed unit processor shall be approved by a consultant or architect and shall use only approved sealant. The necessary test Certificate shall be produced by the processor ensuring the approved sealant and its bite size and application method. Glass supplier shall provide test certificate of Spectrophotometric values

from independent laboratory based in Europe or USA for final clearance. Flatness of both lites of IGU shall be within 2mm per 3mtr span.

4.17.10 THERMAL STRESS

- Submit computations demonstrating the elimination of thermal stress breakage risk, methods of overcoming thermal stress problems, and all assumptions for review and Acceptance. The Contractor shall consider all potential risk locations including but not limited to the following:
 - Heat build-up at shadow boxes and other non-vented spaces/zones.
 - Make provision for internal curtains or blinds within the building envelope framework which may temporarily create non vented spaces prone to heat build-up adjacent to the vision section of the building envelope system.
 - Shadowing effects.
 - Probability of breakage of glass due to anticipated thermal stress in glass shall not exceed 8/1000).

4.17.11 REPLACEMENT OF GLASS:

- Submit details of replacement procedures, including glass size limitations, and equipment required for review and Acceptance. Include estimated maximum lead-time required by the glass manufacturer to supply replacement units for each type of glass unit.

4.17.12 VISUAL EFFECTS, OPACIFIERS AND COATINGS

GENERAL

- Provide coatings and visual effects of paint, coatings or interlayer to glass to match Accepted samples. Submit details.
- Coatings may include:
 - Translucent, colored or patterned interlayer to laminated glass.
 - Surface applied opacifier film to spandrel or vision glass.
 - Decorative painted patterns, colors and textures.
 - Reflective or Low-E solar control coatings.
- Colour, reflectivity and appearance shall be uniform for each glazing type. All clear, coated and tinted glass of each type and thickness shall come from one float line and production run. All glass provided for the project shall match Accepted colour samples and fall within the limits of the colour range allowed.
- Relevant Standards:
 - PBS-4-0885.

GLASS COATINGS

- Glass coatings shall conform to the following criteria:
 - Inspection shall be made at a distance of three meters from the glass for scratches and chips, viewing perpendicular to the glass plane, with any natural light for which flaws are clearly visible. All other imperfections will be viewed at a distance of 300mm.
 - The central area is a square or rectangle concentric with the daylight opening and having width and height respectively equal to 80 percent of the daylight opening width and height.
 - The outer area extends from the border of the central area to the edges of the daylight opening.

- Pinhole diameter shall not exceed 0.8mm in the central area, and 1.5mm in the outer area.
- Within any 300mm diameter circle, there shall be no more than one pinhole with diameter in the range 0.8mm to 1.6mm.
- Scratches, rub marks or other gaps in the coating are not permitted where any portion thereof could include a circle with diameter exceeding 0.8mm. Where the included circle is 0.8mm or less, length of the scratch, rub marks or other gap shall not exceed 25mm in the central area and 75mm in the outer area.
- Streaks or splotches resulting from non-uniformity of the coating that appears visible from the building interior or exterior are not permitted.
- Colour range must fall within the limits established by Accepted samples.
- Relevant Standards:
 - PBS-4-0885
 - BS (EN) 1096
 - ASTM 1376
- DECORATIVE CERAMIC PAINTS
- All ceramic fritted glass shall have ceramic paint applied to the glass using the silkscreen process and fused into the surface of the glass during the heat treatment process.
- Decorative paints with glass substrates shall be from approved vendors accepted by the PMC/Employer. Colour to match project PMC/Employer's approved sample.
- Paint coverage shall be within 6 mm of the edge of the glass.
- All ceramic fritted glass shall be resistant to attack from mechanical damage or abrasion, during normal use and maintenance.
- All ceramic fritted glass shall be resistant to weathering, fading or discoloration due to attack from climatic conditions, UV or atmospheric pollutants.
- The screen-printed surface of the glass shall face the inside of the building in the final construction.
- Defects, including scratches and pinholes shall not be visible when viewed at a distance of 3m.
- Glass shall be Fully Tempered and 100% Heat Soak Tested to EN 14179 part 1.
- Ceramic Colour backing shall be flood coat or pattern frit subject to Ceramic Colour Pattern as specified by the project PMC/Employer.
- Cutting of panels, edge distance for colour coverage and ceramic pattern orientation shall be closely coordinated. Confirm pattern / layout with PMC/Employer prior to the start of mass production.
- All fully tempered Seraphic Glass shall be manufactured, coated and installed with roller-wave distortion, i.e. peak-to-trough-to-peak, undulating vertically.

WARRANTY:

- All decorative ceramic paints shall have a back-to-back warranty of 10yrs.

CERTIFICATION:

- Submit manufacturer's certification that applied films and coatings will not be detrimental to the glass or limit in any way the glass product warranty.

OPACIFYING FILMS: (If required)

- Provide approved opacifying films of polythene or polyester to restrict vision to spandrel areas.
- Film to match project PMC/Employer's approved sample. Opacifier coatings and films are required to be suitable for the proposed temperature and exposure conditions of the glazing and are required to function without bubbling, blistering or colour shift for the design life of the building. Submit details.
- Film shall be fully bonded to glass with solvent based adhesive. Provide safety backing restraint for fallout resistance. Edge deletion of Opacifying films shall be provided at all insulating glass and structural glazing unless manufacturer submits test data acceptable to the project PMC/Employer indicating that edge deletion is not required.
- Opacifier coatings are to be applied to surface 2 of monolithic or surface 4 of insulating glass units and prevent "read-through" of the glass.

OTHER OPACIFYING TREATMENTS:

- Submit pacifying paints and products details for approval.

4.18 ANNEALED FLOAT GLASS**4.18.1 GENERAL**

- Clear float glass shall be in accordance with ASTM C1036, Type 1 and Class 1. Submit details.
- Tinted, heat absorbing float glass shall be in accordance with ASTM C1036, Type 1, Class 2 and Quality Q3. Submit details.
- All glass shall have clean, wheel cut edges with minimum feather, free from vents, notches, or shells.
- Refer to Drawings and Table Vol.II, Sec.9: Materials Schedule, for locations and types of glass.
- Products shall be reputable proprietary products, factory manufactured under ISO 9001. Submit quality assurance documentation for all products, including brought-in products, including ISO 9001 certification, and evidence of satisfactory long-term performance in similar commercial conditions.
- Relevant Standards:
 - ASTM C1036 - Standard specification for flat glass.
 - FGMA - Glazing Manual.
 - IS:2835/1987 Specification for flat transparent sheet glass (third revision)

4.18.2 TOLERANCES:

- Dimensional tolerances of glass generally shall comply with ASTM C036 Table 2.

4.18.3 QUALITY RECORDS:

- Submit inspection and test records to ASTM C1036, Table 4, proportionally adjusted to proposed project glass thickness. Indicate test procedures, acceptance criteria and pass and/or fail rate.

4.18.4 EDGE QUALITY:

- Edge quality criteria for annealed and heat strengthened glass are as follows:
- Shark teeth shall not penetrate more than half of glass thickness.

- Serration hackle may occur only within 150 mm of corners.
- Flare shall not exceed 1 mm measured perpendicular to glass surface across the edge. Flare shall not occur at setting blocks.
- Bevel shall not exceed 1.5 mm.
- Flake chips may occur only within 200 mm of corners. Depth shall not exceed 1 mm and length or diameter shall not exceed 6 mm.
- Rough chips which exceed any of the dimensional limits for flake chips are not permitted.

4.18.5 HEAT TREATED-STRENGTHENED AND FULLY TEMPERED GLASS

GENERAL

- Provide Accepted heat strengthened glass and fully tempered glass, manufactured using the "roller hearth", or an equivalent Accepted horizontal process in accordance with AS 2208, ASTM 1048 and/or ANSI Z97.1. Submit details.
- Base material shall be an Accepted selected quality float glass.
- Relevant Standards:
 - ASTM C1048 - Standard specification for heat-treated flat glass - Kind HS, kind FT coated and uncoated glass.
 - ASTM C1087 - Standard test method for determining compatibility of liquid-applied sealants with accessories used in structural glazing techniques.

EDGE QUALITY:

- Heat treated tempered glass used for but jointed edges with silicone seal shall have belt arised straight, flat ground edges.
- Heat treated glass used for structurally glazing shall have straight, belt arised edges.
- Do not cut, work, or permanently mark after toughening. Use installation methods which prevent the glass making direct contact with metals or other non-resilient materials.

COMPRESSION STRENGTH:

- Toughened glass shall have a surface compression stress of not less than 69 MPa (10,000 psi) and an edge compression of not less than 67 MPa (9700 psi) in accordance with ASTM C1048.

QUALITY RECORDS:

- Submit production and test records to AS/NZS 2208 and/or ASTM 1048. Indicate test procedures, acceptance criteria and pass and/or fail rate.

WARRANTY:

- All toughened glass in single pane applications shall be back-to-back warranty of 10 yrs.

ROLLER WAVE DISTORTION:

- Roller Wave Distortion: in the installed work shall be horizontal unless otherwise approved in writing.
- The maximum roller wave shall not exceed 0.076 mm in any 300mm length of glass.

GLASS DISTORTION:

- Bow Distortion: 'bow' and 'warp' shall have the same meaning.
- Toughening bow shall not exceed 2mm (Max.)

- Distortion / Roller wave shall be max 0.076mm per 300mm and edge curl shall be max 0.25mm
- Refer to relevant section of this specification.
 - BS 6262 - Code of practice for glazing for buildings.
 - AAMA 101 - Voluntary specifications for aluminum prime windows and sliding glass doors.

HEAT-SOAK TESTING:

- 100% heat soak testing will be required for all glass with edge stress exceeding 50mpA (7500 psi).
- Submit Heat Soak method, temperature, and duration for review and acceptance, prior to commencement.

4.19 LAMINATED GLASS**4.19.1 GENERAL**

- Provide all required laminated glass in accordance with AS/NZS 2208 and GANA Glazing Manual.
- Submit details for review and Acceptance.
- The base material shall conform to Section 2.1.2 - Annealed Float Glass and Section 2.1.3 – Heat-treated Glass.
- Glass for laminating is to be cut into individual panels prior to the laminating process.
- Glass thickness of successive panes being laminated together is not to exceed a difference of 2mm.
- Heat treated glass is to be orientated so that warp, bow and roller wave between successive panels are matched. Two stage convection tempering ovens are to be used to ensure glass distortions are minimized. Edge clamping of glass is forbidden
- Relevant Standards:
 - FGMA - Glazing Manual
 - ANSI Z97.1- Glazing materials used in building - Safety performance specifications and methods of testing.

4.19.2 INTERLAYER

- Provide an accepted polyvinyl butyral (PVB) interlayer of required nominal thickness. Submit details including test results for adhesion, durability and compatibility with proposed sealants.
- Products shall be of approved manufacturer.
- Special performance films such as California Series XIR must be fully encapsulated in the PVB with 10mm overlap at edges and bolt holes.

4.19.3 EDGE QUALITY

- All laminated glass shall have clean cut edges, or polished edges if required to eliminate thermal stress breakage risk. Laminated glass units shall be fabricated with autoclaved edges on all four sides.

- The edges of laminated glass are to be protected to prevent delamination, contamination or other defects, caused by moisture, sealant contact or other external/internal sources.
- All exposed laminated glass edges shall be protected from blushing by hot rolling the interlayer back into the glass edge, or by use of an approved edge seal material.

4.19.4 QUALITY RECORDS

- Submit production and test records to AS/NZS 2208, ANSI Z97.1 and/or ASTM 1048, BS 6206.
- Indicate test procedures, acceptance criteria and pass and/or fail rate. Include records for interlayer.
- Provide daily records of maximum factory temperature and humidity and weekly records of water quality used for washing glass. In the event that Interlayer Supplier application requirements are not satisfied, batches of non-complying glass shall be rejected.

4.19.5 WARRANTY

- All laminated glass in single pane applications shall have a back-to-back warranty of 10 yrs.

4.19.6 INSTALLATION

- Use glazing materials which do not cause deterioration or discoloration of the interlayer.
- Submit test results to confirm the compatibility of laminated glass with adjacent glazing materials.

4.19.7 INSULATING GLASS UNIT

GENERAL

- Provide Insulating Glass Units (IGUs) (also known as double-glazed units) of Accepted types in accordance with ASTM E2190, AS/NZS 2208, and the recommendations of IGMA. Submit complete details, including all construction details, primary and secondary seals, gas filling and corner treatment, nature of spacers, evacuation and assembly process.
- Relevant Standards:
 - ASTM C1087 - Standard test method for determining compatibility of liquid-applied sealants with accessories used in structural glazing techniques.
 - ASTM E546 - Test for dew point of sealed insulating glass units.
 - ASTM E773 - Standard test methods for seal durability of sealed insulating glass units.
 - ASTM E774 - Standard specification for sealed insulating glass units.
 - IGMA - Insulating Glass Manufacturer's Alliance.

SEAL PERFORMANCE

- IGUs shall incorporate Accepted polyisobutylene primary (vapor) seals continuously bonded to glass, and two-part silicone secondary (structural) seals. Primary seal shall be not less than 3 mm deep. The secondary seal

shall completely cover the spacer with no gaps or voids, continuously bonded to glass.

- In cases where the thickness of the outboard lite is greater than that of the inboard lite, the 50/50 load sharing (or 50 percent of structural bite) is no longer valid and the load-sharing must be determined.
- Spacer bar shall be a proprietary aluminum type, desiccant filled, anodized in a colour compatible with seals. Conceal the spacer bar within the depth of the glazing gasket line to ensure smooth sightline. Submit details and colour samples for review and Acceptance.

STRUCTURAL EDGE DISTANCES

- Submit, for review and Acceptance, computations for distance between the outer edge of the glass and the innermost edge of the aluminum spacer indicating minimum bite of secondary (structural) seal and spacer bar depth. Include sealant manufacturer's recommendations and load tables.

EDGE QUALITY

- Heat treated glass lights of IGUs shall have clean cut edges. Internal toughened lights of IGUs shall have bevelled edges.

QUALITY RECORDS

- Submit production and test records for IGUs. Indicate test procedures, acceptance criteria and pass/fail rate to AS/NZS 2208 or an equivalent Standards

TESTING

- Submit report from an accredited and approved testing laboratory the unit type has attained Class A as defined in ASTM E2190 when tested in accordance ASTM E2190.

WARRANTY

- All IGUs complete shall have a back-to-back warranty of 10 yrs. For a period not less than the warranty period, all IGUs shall be free from evidence of manufacturing defects and shall be free from:
 - Intrusion of moisture or dirt.
 - Internal condensation at temperatures above -10o C-degrees.
 - Other visual evidence of seal failure or performance failure.

4.20 LOW-E GLASS UNIT

4.20.1 GENERAL

- Low-emissivity (low-e) coating(s) shall be neutral in transmitted and reflected colour and otherwise exhibit the visual and performance characteristics of the products specified and shall comply with ASTM C 1376.
- The coating shall be approved by the project PMC/Employer and fall within the limits of the colour range allowed.
- Colour difference shall not exceed 3 E Hunter.
- Visual Quality Control acceptance criteria of the low-e coating shall be consistent with industry guidelines, subject to approval by the project PMC/Employer.
- Pinholes with diameters shall not exceed 0.8mm in the central area, and 1.5mm in the outer area of the glass panel.

- Clusters of pinholes are not acceptable.
- Streaks or splotches resulting from non-uniformity of the coating that appears visible from the building interior or exterior are not permitted.
- Scratches no longer than 75 mm in length are acceptable provided that they occur within 75 mm of an edge.
- Edge deletion of low-e coatings shall be provided at all insulating glass and structural glazing unless manufacturer submits test data acceptable to the project PMC/Employer indicating that edge deletion is not required.
- The contractor shall ensure that the coating (s) conforms to the codes and regulations. Any fees incurred from an application of waiver and variance shall be the responsibility of the Contractor.
- Manufacturer shall warrant that low-e coating shall not peel, crack, fade or deteriorate for a period of ten (10) years. The manufacturer shall warrant that any glass that is not edge deleted will not develop loss of adhesion with insulating glass or structural glazing sealants for a period of ten (10) years.

4.20.2 TERRACE COPING

- Copping at terrace level sealing the glazing system and parapet wall shall be of 3mmthk solid aluminum sheet cladding / 4mm thick. ACP in PVDF finish / Al. Extrusion with required Aluminum structural back up support designed for wind load.
- Additional stiffeners shall be provided in the form of top hat profile running continuous length wise and connected mechanically at panel joint returns.
- Joints at the grid center shall have weather sealant covered with Aluminum Cap on top to avoid any insect or birds damaging sealant as 1st barrier and GI Sheet laid under to provide 2nd barrier for weather.

4.20.3 STRUCTURAL STEEL

- Façade structural steel works shall be a part of façade contractor scope, unless noted in tender drawing clearly. Scope of work shall be Design, supply, fabrication, surface treatment, storage, delivery & erection of all the steelwork. This also includes the supply and installation of all cast-in items used to support the steelwork, the grouting of base plates, the provision of cleats and drilling of holes for the attachment of the cladding system, and repairs to damage surfaces during construction.
- The work shall be carried out in strict accordance with the Façade contractor's drawings (to be reviewed and Accepted by the Consultant / PMC / Architect), this specification, all other drawings and specifications included in this contract, and any Contractor authorized written instruction that may be issued during the course of this project.
- Facade contractor shall comply all applicable Indian Regulations / Standard, British standard, but not limited to the following standard as specified.
 - IS 800 – 2007: General Construction in Steel – Code of Practice
 - BS EN 10025: Hot rolled products of structural steels
 - BS 638: Arc Welding Plant, Equipment and Accessories
 - BS 639: Covered Electrodes

- BS 709: Methods of Non-Destructive Testing Fusion Welded Joints
- BS 729: Hot Dip Galvanized Coatings on Iron and Steel Articles
- BS 916: Black Bolts, Screws and Nuts
- BS 1449: Steel Plate, Flat and Strip
- BS EN ISO 1461: Hot Dip Galvanized coatings on fabricated iron & steel articles
- BS 1580: Unified Screw Threads
- BS 2600: Methods for Radiographic Examination of Fusion Welded Butt Joints in Steel
- BS 2910: Methods for Radiographic Examination of Fusion Welded Circumferential Butt Joints in Steel Pipes
- BS 2989: Specification for continuously hot-dip zinc coated and iron-zinc alloy coated steel
- BS 3019: TIG welding
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- BS 3100: Steel Castings for General Engineering Purposes
- BS 3571: MIG welding
- BS 3889: Methods of Non-Destructive Testing of Pipes and Tubes
- BS 3923: Methods Ultrasonic Examination of Welds
- BS 4165: Electrode Wires and Fluxes for the Submerged Arc Welding of Carbon Steel and Medium Tensile Steel
- BS 4190: ISO Metric Black Hexagon Bolts, Screws and Nut
- BS 4232: Surface Finish of Blast Cleaned Steel or Painting
- BS 4320: Metal Washers for General Engineering Purposes
- BS 4360: Weld able Structural Steel
- BS 4515: Field Welding of Carbon Steel Pipelines
- BS 4848: Hot Rolled Structural Steel Sections
- BS 4871: Approval Testing of Welders
- BS 4882: Bolting for Flanges and Pressure Containing Purposes
- BS 5135: Metal Arc Welding of Carbon and Carbon Manganese Steels
- BS 5400: Part 6 - Fabrication tolerance for steel work
- BS 5493: Protective Coating of Iron and Steel against Corrosion
- BS 5950: Part 2 - Fabrication tolerance for steel work
- BS 6072: Method of Magnetic Particle Flaw Detection
- BS 6323: Seamless and Welded Steel Tube
- BS 6399.1: Code of Practice for Dead and Imposed Loads
- BS 6399.2: Code of Practice for Wind Loads
- BS 5588: Fire Precautions in Design, Construction and Use of Building
- BS 5588: Part 3(1983) - Code of Practice for Office Buildings
- BS 7543: Guide of Durability of buildings and building elements, products and components
- BS 476: Fire tests on Building Materials and Structures
- BS 6651: Code of Practice for the Protection of Structures against Lightning
- IS 800 – 2007: Code of Practice for General Construction in steel
- IS 2062: Hot rolled Low, Medium and High Tensile Structural steel.

- IS 801: Code of Practice for use of Cold-Formed Light Gauge Steel Structural Members in general Building Construction.
- IS 806: Code of Practice for use of Steel Tubes in General Building Construction.
- IS 808 – 1989: Dimensions for hot rolled steel beams, columns. Channels & angle sections.
- IS 811: Specification for cold formed Light Gauge Structural Steel Sections.
- IS 816: Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel
- IS 1161: Steel Tubes for Structural Purposes - Specification
- IS 1477: Code of Practice for Painting of Ferrous Metals in Buildings & Allied Finishes
- IS 7215: Tolerances for fabrication of steel structure
- IS 12843: Tolerance for erection of steel structure
- S15 055900: Surface Preparation for Painting Steel Surfaces
- American Welding Standards
- AWS D1.1-84, 1986: Citect Monograph 9

4.20.4 MATERIAL

- All material shall be confirmed to Weld able structural steel confirming to BS EN 10210 Grade S275(Mild steel) or Grade S355 (High Yield steel)
- Hot Rolled sections.
- All Structure shall be complied with following standard.
 - Universal beams, columns, tee sections & channels to BS 4
 - Hollow sections to BS EN 10210-2
 - Angles to BS EN 10056-1
 - Flats, plates, bars to BS EN 10210
- Cold Rolled Sections:
 - All Structure shall be complying with BS EN 10162.
 - Cold roller sections are not permitted unless specially mentioned in the drawings.
- Cast Iron & Cast Steel
 - Grey cast iron shall confirm with BS EN 1561, grade 10
 - Malleable cast iron shall confirm with BS EN 1562
 - Spheroidal cast iron shall confirm with BS EN 1563
 - Carbon manganese steel castings shall comply with BS EN 10293
- Stainless Steel
 - Wrought Stainless Steel shall confirm with BS EN 10083, Grade S16
 - Flat rolled Stainless steel shall confirm with BS 1449 & Grade 316 S16 softened
 - Stainless steel tubes shall confirm with BS EN 10296, designation LW 23 GZF(S)
- Forged Steel
 - Steel forgings shall confirm with BS EN 10250-2

4.20.5 WELDING

- Welding procedure (Consumables used / Tools / Method / Angle of weld/ Number of welding pass) shall be submitted for consultant review
- All welding shall confirm with BS EN 1011-1
- Welding consumables for fusion welding shall be confirm with BS EN 1011-8
- Welding consumables for metal arc welding of austenitic stainless steel shall be confirm with BS 4677
- The minimum weld size should be 5mm (depending on the member size lower thickness weld can be used subject to consultant's approval.)

4.20.6 FORGED STEEL WELDING CONSUMABLES

- All welding of structural steel shall comply with BS EN 1011-1. Welding consumables used in fusion welding shall comply with BS EN 1011-8. Welding consumables used in metal arc welding of austenitic stainless steel shall comply with BS 4677.
- Welding consumables and the procedures used shall ensure that the mechanical properties of the deposited weld metal shall not be less than the parent metals.

FORGED STEEL PREPARATION FOR WELDING

- Prepare fusion surfaces to BS EN 1011-1. Surfaces must be dry. Warm the surfaces if required to remove condensation.
- Remove welding slag by chipping before depositing subsequent runs.

TYPES OF WELDS

- **Forged Steel Tack welds**
 - Tack welding may only be used with express approval. Tack welds to be minimum 50mm long.
- **Forged Steel Butt welds**
 - Butt welds shall be full penetration welds between prepared fusion faces, unless otherwise specified. Carry out back chipping, grinding or gouging of the deposited weld as required to obviate imperfections in the root run. Grind butt welds flush without loss of parent metal.
- **Forged Steel Fillet welds**
 - Deposit fillet welds to the required length, throat thickness and with partial or full penetration as specified.

WELD TESTING**GENERAL**

- Provide an experienced and competent operator to supervise welding. Submit certificates proving that all welders have passed the training tests in BS1295 and if specified, carry out approval tests to BS EN 287-1 or BS 4872: Pt. 1 as applicable.
- Keep a record on Site when specified to identify welders responsible for major welds
- Obtain Acceptance of the proposed welding procedures prior to commencing welding including

- Preparation of fusion faces
- Preheating temperature where required
- Type of electrodes
- Number and sequence of runs to build-up the weld bead
- Post-heating treatment if required.
- Do not depart from the agreed welding procedure without the prior agreement of the Contractor.
- Carry out approval testing of welding procedures to DIN EN ISO 15614-1, when specified, strictly in accordance with the proposed welding procedure using representative samples of the materials.

BUTT WELD

- Carry out the following tests:
 - Transverse tensile tests to BS EN 10002-
 - Transverse bend tests to BS EN ISO 7438, with the root of the weld in tension and compression respectively.
 - Side bend tests.
 - Macro-examinations

FILLET WELDS

- Carry out the following tests:
 - Fracture test.
 - Macro-examinations
- Strictly follow the procedures of welding established in the successful approval test for the works.
- Carry out further approval tests if either the material or procedure changes

EXTENT OF TESTING

- Weld testing is to be carried out by an independent Accepted Testing Company. The following testing is required:

Weld Description	Connection Type	Visual	Ultrasonic or X-ray or MPI
Fillet Welds			
All plates less than 12mm	Secondary	25 %	-
	Primary	50 %	10 %
Plates between 12 and 24mm	Secondary	50 %	10 %
	Primary	100 %	25 %
Plates over 24mm	Secondary	100 %	25 %
	Primary	100 %	100 %
Butt Welds			
All	-all-	100 %	100 % (no MPI)
Combination butt fillets			
Tubes < 10mm		100 %	25 %
Tubes > 10mm		100 %	100 %
Note: Secondary connections are to minor cleats, stiffener plates etc..			
Primary connections are at the ends of a member			

4.20.7 QUALITY MANUAL

- Facade contractor shall submit the document & maintain an inspection and testing system should be confirming the specification. All test certificates shall be provided for all steel works in accordance with BS EN 10002-1
- All the welders shall be trained as per BS 1295

4.20.8 PROTECTIVE COATING

- All steel shall be provided with a protective coating with 25years minimum design life. Complete method statement to be submitted by the contractor.
 - **External concealed Steel work**
 - ❖ Shall be hot dip galvanised with a minimum 100 micron
 - **External exposed Steel work**
 - ❖ Surface Preparation – Blast cleaned to Sa 2.5 confirming to BS EN ISO 8501-1
 - ❖ Primer: Zinc Rich Epoxy 75 micron
 - ❖ Barrier: Epoxy Mio 125 micron
 - ❖ Finish: Polyurethane – 50 Micron (Only for exposed steel)
 - **Internal concealed Steel work**
 - ❖ Shall be hot dip galvanised with a minimum 70 micron
 - **Internal exposed Steel work**
 - ❖ Surface Preparation – Blast cleaned to Sa 2.5 confirming to BS EN ISO 8501-1
 - ❖ Primer: Zinc Rich Epoxy 75 micron
 - ❖ Barrier: Epoxy Mio 125 micron
 - ❖ Finish: Polyurethane – 50 Micron (Only for exposed steel)

4.20.9 FIRE-PROOFING MATERIAL:

- The sprayed fireproofing material shall be an intumescent paint type fireproofing unless noted otherwise. All structural steelwork where specified shall be protected by Accepted fireproofing material and must be Accepted by local authorities.
- All manufactured material shall be delivered in original, unopened packages bearing the name of the manufacturer, the brand, and a recognised testing body's label verifying compliance with said body's quality control inspection programme and the appropriate fire resistance ratings.

4.21 STAINLESS STEEL:**General**

- Provide all stainless steel in the required profiles finishes sizes and grades.
- Stainless steel is generally Grade 304 or 316. Grade 302 shall not be used. Structural applications and all exposed stainless-steel works shall be Grade 316.
- Provide 1.0mm radius at all corners with 'v-cut' where necessary.
- All stainless steel is to be a minimum thickness of 2.0mm.

- Relevant Standards:
 - AS 1449
 - BS1449: Part 2
 - ASTM A666

Mechanical finish:

- Unless otherwise indicated on Drawings, exposed stainless steel shall be finished to match
- Accepted samples in accordance with AS 1449, designated as follows:
 - "Finished".
 - "6" Soft satin.
 - "7" Semi-mirror.
 - "8" Bright mirror.
- Grain shall be vertical in all locations, unless otherwise indicated on the Drawings, surface roughness Ra <20 to avoid tea staining corrosion.

Flatness

- Flatness of stainless steel shall be not less than "stretcher level" grade. Submit manufacturer's specifications.
- Panel deflection criteria: deflection normal to the plane of construction shall be limited to as per codal norms. This deflection is to be measured in relation to the actual (deflected) position of the supporting member.

Colour

- Where indicated on the Drawings to be colour finished, stainless steel is colour treated by an accepted permanent process to match Accepted colour samples. Submit details.

Certification

- Submit certificate of compliance or test report and properly identify each batch of stainless steel in accordance with the relevant standard.

5.0 QUALITY ASSURANCE:

- The project specific quality plan should be produced to demonstrate the quality management system implemented from award of contract to contract completion. Quality plan to include design plan, design Verification, validation procedure, inspection procedures and check list at all stages of work.
- Qualification of manufacturers: Products used in the work shall be in line with the approved vendor list and produced by manufacturers regularly engaged in manufacturing of similar items and with a history of successful production acceptable to Employer/Architect.
- Glazing & Cladding Contractor's qualification: The glazing contractor who is regularly engaged and successfully performed in engineering, fabrication and installation of similar comparable project in unitized, semi-unitized and point fixed suspended glazing & dry-stone cladding over the last Five years.
- All the work shall be executed only by pre-qualified specialized contractor under single point responsibility for suspended point fixed glazing and cladding having experience in design & engineering, fabrication and installation in similar kind of projects. Point fix glazing design & installation shall be the responsibility of hardware supplier.

- Subcontracting of any part of work by specialized Glazing agency shall be strictly on approval by the Clients/ Architects/specialized consultant.
- **Source Quality Control**
 - Shop and field materials and workmanship activities shall be subject to inspection by the Architect and or façade consultant or their representative at all times. Such an inspection does not relieve the Contractor from obligations to provide materials conforming to all requirements of the Contract Documents and industry standards for material quality.
- Each bidder shall submit with his bid Project proposal Shop Drawings for Employer/Architect's review.

5.1 Design responsibility

- The tender drawings and performance requirements are design intent of the Architect and are preferred profile system with science and technicalities as demonstrated. The total responsibility of system design meeting the performance requirement lies with the glazing contractor. The system shall go through necessary corrections till it passes all the required performance criteria in the performance tests.
- The glazing contractor is responsible for design, engineering calculation for each element and components & preparing shop drawings fully acceptable to the Architect and façade consultant.
- The glazing contractor is to take in to account the wind loads, dead loads, building movements, earthquake movements, thermal expansions and contraction resulting from the ambient temperature range of 15 to 45deg C variance including surface temperatures up to 80degcel. The design must account for cracking sound, combined stresses on the components, sealants, glass and joint seals without any damaging effects.

5.2 Water penetration.

- The system design of the Unitized system to be based on three barriers, and pressure equalization principle with effective drainage system to drain out uncontrolled water entering first barrier of the gasket. The system must provide pressure release slots in the spandrel panel to eliminate condensation and water leakage due to condensation and pressure built up. The system shall have proper sealing from inside for air and vapor barrier, also effective weather barrier at 2nd level gasket defense with effective drainage system & pressure equalization slots thru 1st barrier gaskets to ensure that the pressure equalization system will operate adequately even under the most severe rain periods and also during severe wind effect expected in the area. The glass joints must be limited to 15-20 mm with open joints with no sealants exposed in the grooves.
- The façade contractor shall provide complete path of water drainage in shop drawings.
- All exposed weather sealing gaskets shall be EPDM gaskets also when in contact with silicone and unexposed must be of EPDM microwave cured to prevent deformation due to temperature effect and weathering. The operable

vents, if any given in the system must be provided with multipoint locking mechanism to keep the system sealed under severe wind load and rainy condition. The continuous gutter formation at each floor must be sealed properly and tested before the upper units are installed over them.

- The provision of hard EPDM rubber setting blocks at every glass bottom fixed at W/4 distance to support the dead load of the glass
- All movable frames like outer frames & shutter frames shall have crimped (and sealed) corner joints to avoid failure of the corner joints at later stage under load condition.
- The provision to be made for gondola restrains pins and lightning system to pass through Curtain wall as per the project requirement.

5.3 Sealant

- Execute design review, silicone bite size recommendation, surface preparations, compatibility test of all materials and final recommendation to be called from silicone supplier for IGU sealant. IGU sealant application to be carried out under controlled condition and with two-part IGU silicone as per approved make . Execute adhesion testing the record maintained recommended by silicone supplier along with the required tests Butterfly test, snap time test, shore A hardness test, peel adhesion test to be performed and recorded.
- The weather sealant applied at the perimeter joints and interfaces shall be of non-staining kind and able to withstand the building movements and seismic movement without any failure. The size of the sealant at the perimeter shall be determined based on the movements and shall not be less than 15 mm.
- The sealant compatibility test shall be carried out with a kind of granite stone cladding to ensure non reacting kind sealants and non-staining of stone over a period.

6.0 PERFORMANCE TESTING:

- Performance test, if required, shall be carried for the different wall types as per Annexure No: 03
- Façade contractor to carry out the performance test in a NABL accredited laboratory approved by PMC/Employer:
- Supply and erect off-site full-scale building envelope Test Performance Prototypes for façade testing in accordance with the Specifications, including a suitable simulated building frame, and incorporating at least one example of each repetitive design element and construction method in the system, as indicated on the Drawings. Testing shall include structural performance, air infiltration, water penetration, seismic raking, and proof-load testing and visual assessment.
- The test prototypes will be Accepted subject to the successfully carrying out of the test program and the submission of all specified requirements, and the satisfactory passing of all structural performance, seismic raking, air infiltration, water penetration and proof criteria by the testing laboratory. When accepted,

the test prototype shall be the accepted control standard for the contract works. Test panels and components shall not be re-used in the contract works.

- Submit details of the proposed laboratory, including curriculum vitae of the testing officer in charge. Submit a detailed and sequential outline of the proposed test procedure with schematic diagrams describing the type and location of all data collection instruments. The proposed testing program and procedure shall be accepted prior to the commencement of testing.
- The Contractor shall submit a testing Plan and carry out all testing and commissioning of the Building Envelope systems.
- The Contractor prepares and submits to the PMC/Employer, for review and Acceptance the overall test schedule, prior to the commencement of any tests. The Test Plan shall include, but is not limited to the following items:
 - A detailed description of the tests to be performed.
 - A detailed description of the conditions under which the test shall be conducted and accepted.
 - A schedule of actions to be taken in the testing of the various parts of the building envelope and the forms of documentation of the test results.
- The purpose of the tests shall be to demonstrate compliance with all of the performance and technical specifications set out in the Specifications and with the requirements set out in the MCoC
- Testing shall be carried out in a number of phases, including, but not limited, to:
 - Tests during manufacture and Project site Tests
 - Pre-Commissioning
 - Commissioning
 - Performance Tests
 - Integration Tests
- The testing agency shall carry out onsite tests as specified and the cost of the same shall be included by the contractor.
- The cost of visit of 6 persons i.e., Client representative, architect and consultant to witness the test shall be included.
- After approval of Mock-up Elevation, Shop drawings and structural calculations the mock-up test units of the curtain wall for performance testing shall be constructed by the Contractor at the testing laboratory.
- The Contractor shall forward the copies of approved mockup elevation and shop drawings to the Test Laboratory prior to installation of the test units. These drawings shall include:
 - Test elevation and sections.
 - Full scale typical details of façade panels
 - Typical support details
 - Extent of sealants
 - Method of installation
- Any deviations from the drawings shall be agreed upon before commencement and recorded in the final test report.
- The registered testing laboratory shall be an approved independent laboratory which conducts testing in accordance with ISO/IEC 17025:2005 "General

Requirements for the competence of testing and calibration laboratories" is considered technically adequate subject to test procedure / resources and project requirements.

6.1 TEST UNITS:

- The test units shall comprise components representative both in size and shape of the facade of the building under examination. The width of the test sample shall be not less than three typical adjoining wall panels/units. The height of the test sample shall be full height modules of the Glazing. Vertical and horizontal movement joints shall be included in the test sample.
- Where details of the building facade differ from those in the representative test sample, such as critical corners, overhangs and the like, supplementary on-site test shall be performed for water tightness on such part of the facade.
- The materials of the test sample (glass thickness, size and strength, aluminum profiles, bracket spanning, sealant, gaskets, accessories etc.) shall be of the sample, type and size and have the same details, methods of construction, flashing and anchorage as the building facade.
- If not actual on-site representative sample of the wall of the building, the test sample shall be mounted and sealed into a simulated building frame in the same manner and by the same fixing which are intended to attach the facade to the building structure. The support frame shall be of equivalent stiffness to the supporting the building to prevent unrealistic deflection of the prototype sample.
- Simulated floor slabs and spandrel shall be to actual depth if for example in curtain walls the air seal is connected to the slab. The internal finishes and linings shall be installed where they contribute to the air seal of the facade. The air seal of the test sample shall be continued to the air seal of the test chamber.
- All panels and other interconnected joints in the facade shall be sealed at the sample boundaries. This is to minimize the effects that the surrounding construction will have on the test performance of the sample. All pressure equalization and drainage slots or holes in the test sample shall be left open.
- Transparent viewing panels (or other means of observation such as an optical fiber probe) shall be provided so that the performance of the facade in areas that are not readily seen can be determined.

6.2 INSPECTION OF TEST UNITS

- The Contractor shall allow the Project Consultant to inspect the test sample regularly during erection. At this stage the adequacy and stiffness of the support structure shall be assessed. When the installation of the test sample is complete, the Project Consultant shall inspect the test sample and, if satisfied, shall approve its completeness.
- Submit notice in writing of proposed commencement of the Performance Testing, complete with Program, not less than 1 month before commencement. The testing shall include all actual jobsite components, including all glazing configurations, sealants, adhesives and gaskets. Instruments and gauges shall

be selected, tested and located by the testing officer-in-charge in consultation with the PMC/Employer

- Testing shall not commence until this approval has been given.
- Full-time attendance by approved representatives of the contractor shall be provided for the erection of the test unit and all testing of the test units.
- Unless otherwise specified the test-sequence shall be as follows:
 - 50% Structural load
 - Vent Open Close 5 times.
 - Air Infiltration test – (As per ASTM E 283)
 - Static Water Test – (As per ASTM E 331) – No leakage
 - Dynamic Water Test – (As per AAMA 501.1) – No leakage
 - Structural Wind load Test – (As per ASTM E 330)
 - Repeat Static Water Test – (As per ASTM E 331) – No leakage.
 - Proof Load Test – (As per ASTM E 330)
 - Seismic rack test - +/- 10mm movement (as per AAMA 501-4.09) – No failure
 - The test parameters would be in line with NBC 2016
- A BMU Tie Back shall be tested in all directions (for values of loads to be applied, refer to the relevant section of this specification). A static pressure of 0.5 kPa shall be applied for the duration of the testing. The Tie back shall not fail, exhibit permanent distortion, or interfere with the performance of the curtain wall and related seals.
- Degradation Testing: If deemed necessary by the project PMC/Employer on completion of the structural testing, a further series of water penetration tests shall be undertaken with portions of various gaskets and sealant beads removed on each test assembly. The purpose of such testing is to simulate the effects of degradation and failure of such seals and is carried out for information only.
- Air infiltration test shall confirm to ASTM E 283-04. Differential static test pressure shall be 150Pa. Chamber leakage shall be accurately determined, not estimated. Air leakage of test specimen shall not exceed 1.5 m³/hr.m² on fixed and 2.0m³/hr.m of crack length of vent on the openable window as per NBC-2016 (Annex F – Clause 8.2.1).
- The occurrence of condensation during water infiltration tests is acceptable. Other water leakages are acceptable only if all of the following conditions are satisfied.
- The water is contained and drained to the exterior.
 - There is no wetting of surface that would be visible to building occupants.
 - There would be no staining or other damage to any part of the completed building or its finishing. This definition of water leakage shall govern over other definitions that may appear in referenced documents. State criteria of temperature and humidity.
- Where the test sequence or test failures requires successive water infiltration tests. The only means used to drain water from internal cavities shall be gravity drainage through the weep systems (pressure equalization system) for a

minimum of 10 minutes. Air pressure removal of parts or other means of draining water not to be used.

- The Static water infiltration test shall conform to ASTM E 331-00, except as otherwise specified herein. Differential test pressure shall be 450 Pa. There shall be no unacceptable water leakage as defined herein.
- Dynamic water infiltration test shall conform to AAMA 501.1 except as otherwise specified herein. Differential test pressure shall be 450 Pa. There shall be no unacceptable water leakage as defined herein.
- The structural test shall conform to ASTM E 330. Deflection gauges shall be set zero prior to each application of pressure at 50 & 100 % of design pressure. Deflection gauge readings shall be recorded after each application of pressure. Deflection measurements are not required for the initial preload.
 - Structural loads (ASTM E 330-70) held for ten seconds each as follows.
 - ❖ 50% positive pressure – design load (To remove the slack)
 - ❖ 100% positive design load.
 - ❖ 50% negative pressure – design load (to remove the slack)
 - ❖ 100% negative design load.
 - Typical deflections at the above loads will be measured with micrometer dial indicators or Displacement transducers.
 - Supplementary loads (ASTM E 330-70) held for ten seconds as follows:
 - ❖ 50% Positive design pressure (to remove slack)
 - ❖ 150% Positive Design Pressure (1.5 * design load)
 - ❖ 50% Suction Design Load (to remove slack)
 - ❖ 150% Suction Design Load (1.5 design load)
 - Failures in glass breakage not allowed. Permanent deformation in Aluminum structural members and Aluminum Composite Panel in excess of L/1000 is not allowed.
- Mock-up test as per the sequence specified above shall be carried out till system finally passes with corrections.

6.3 Field test on actual building-Hose Test:

- Hose test for water leakage shall be carried out confirming to AAMA 501.2-03 by the same independent test agency at 8-10 locations as desired by the architect / consultant. Initial installation of 4 units by two floor height to be tested to check the workmanship in line with the design intent and performance. The locations are typical building façade, different corners of the building, coping, critical roof glazing junctions and inclined glazing corners.
- There shall be no water leakage.
- This test to be conducted by NABL accredited third party laboratory only.
- Begin testing as early as possible i.e. 5 % of installation during erection so that approved corrections can be incorporated into the remaining work.
- Correct defects revealed by test. Retest corrected work to determine effectiveness of remedial measures.

- Provide power, scaffold, water supply and manpower to perform test as desired locations till successful tests. The test areas shall be as selected by PMC/Employer/ Architect.
- PMC/Employer/Architect will select typical areas to be tested, each equivalent to three bays wide and two Stories high.
- Corrective measure shall meet standards of quality represented by successfully tested mock-ups and are subject to Employer/Architect.
- Sealant: Periodically test sealants in place in place for adhesion, using methods recommended by sealant manufacturer. Promptly replace sealant that does not adhere or fails to cure.

6.4 Material Testing:

- Brackets, Aluminum Studs and Screw Fixings: Arrange and pay for testing at the accepted laboratory and submit test result for components as follows:
 - Fixing brackets:
 - ❖ Test a minimum of 3 brackets and embedment fixed to the base structure for each fixing condition. The brackets shall be fixed to prefabricated concrete blocks which exactly represent the base structure in relation to edge distances, reinforcement and concrete strength.
 - ❖ Prepare and submit shop drawings prior to fabrication of the concrete blocks. Be responsible for making and transporting the concrete blocks to the testing laboratory.
 - ❖ Install test fixings in accordance with Accepted shop drawings but locate with most adverse tolerances and application of loads. Acceptance of the fixing system is dependent on each test failure load being at least 3x the design working load for concrete failure, 2x for metal failure and the absence of permanent deformation at 1.5 x the design load.
 - ❖ The test report shall be submitted and accepted prior to casting-in any embedment or fixings into the structure.
 - Aluminum stud fixings
 - ❖ Where required for fixing face sheeting to support frames, provide not less than M6 fully threaded welded studs of approved type, and welded according to AWS C5.4. Prior to the start of fabrication, demonstrate the strength of welded aluminum stud fixings by testing in tension to destruction six fixings attached to test panels cut from sheets identical to the permanent aluminum panels. Repeat process at 30% and 60% stages of the fabrication program. Submit a test report prepared by the Accepted laboratory prior to the start of fabrication.
 - ❖ Test all studs on 1 panel out of 10 to 1.5 times design load. Record and submit records when requested. Any failure will require 100% testing of the particular batch.
 - ❖ Acceptance of the fixing system is dependent on the average of each set of six test failure loads being at least twice the design load and the absence of permanent deformation at 1.5 times the design load.

- Screws secured in extrusion flutes:
 - ❖ Demonstrate the strength of each connection by testing 18 screws in accordance with AS 1664 or an equivalent Standard. Stagger tests in groups of 6. The test report shall be submitted and accepted prior to fabrication. Any works that are carried out prior to successful completion of the tests will be at the Contractors own risk.
- Silicone compatibility testing:
 - ❖ Test procedures and minimum acceptance criteria shall comply with AAMA CW 13.
 - ❖ Sealant - Adhesion and compatibility testing: Submit manufacturer's test reports prepared by the accepted lab to conduct sealant test for all structural adhesives (silicone) used in structural glazing before commencing installation. Include details of sampling and test procedures. Carry out and submit results for initial adhesion and compatibility testing by the Accepted laboratory including "peel" tests to ASTM C794 and ASTM C510. Verify unconditional acceptance of all materials in contact with structural adhesives, and that no material in contact with the structural adhesives will cause deterioration of structural adhesives, and the structural adhesives will not cause intrusion into laminated glass interlayer or IGU seals.
 - ❖ Sealant - Direct tension tests: Carry out and submit results for direct tension tests by the Accepted laboratory on samples of vision glass and spandrel glass adhered to finished aluminum. Use an Instron Tensile Tester, or Accepted alternative. Test ten samples of each joint type without weather seals and using actual materials and joint configuration identical to that proposed and complete testing prior to manufacture, as follows:
 - Five samples shall be air-cured 21 days then water immersed 7 days before testing.
 - Repeat procedure on completion of manufacture of 30% of the materials.
 - Apply a 5x safety factor to the mean of the ultimate strength results to determine joint dimension. Complete initial tests prior to commencement of manufacture.
- Sealant - Adhesion (de-glazing) tests: Carry out and submit results for factory adhesion (de-glazing) tests to fully cured glazed panels selected randomly. Cut joint at midpoint to leave half the sealant attached to the glass and half to the substrate. Carry out visual examination of joint fill, voiding and structural bite adhesion. After testing fully remove silicone tape and spacers, thoroughly clean and re-apply sealant in accordance with Accepted procedures in the factory. Testing shall be carried out at the rate as follows:
 - One unit in the first 10 units was delivered to site
 - One unit in the next 40.
 - One unit in the next 50.
 - One unit in each 100 thereafter.
- After testing, replace the adhesive by Accepted factory procedures.
- Any unsatisfactory occurrence including lack of joint fill, lack of adhesion, excessive voiding or other defect be apparent, may be grounds for all units

represented by that testing to be rejected. Carry out additional testing of units manufactured on the same day and one day either side (a further five units). Such units may be accepted on the condition that a satisfactory explanation of such occurrence is submitted and that no additional unsatisfactory occurrences occur.

- Sealant - Peel tests during glazing: Carry out periodic "hand pull" peel tests in the factory on finished metal samples out at a rate of one per day. A silicone bead shall be applied to an area not exposed to view in the final location, on a random basis. After curing, a peel test shall be performed to demonstrate adhesion. Record results in glazier's logbook. Submit copies at weekly intervals.
- Prototype de-glaze: At completion of testing, de-glaze and replace one vision and one spandrel glass pane in accordance with proposed re-glazing procedure to demonstrate the procedure to the PMC/Employer. Acceptance: Production of building envelope systems shall not proceed until final test results have been accepted.
- Structural glazing restraint testing: Samples of the secondary cover mold restraints shall be tested to demonstrate structural integrity in the event of structural glazing adhesion failure. Structural silicone shall be cut to simulate total adhesion failure and cover mold restraints fitted and tested.
- Structural Glazing Testing: Submit manufacturer's test reports prepared by the Accepted laboratory for all structural adhesives (silicone) used in structural glazing before commencing installation. Include details of sampling and test procedures. Test procedures and minimum acceptance criteria shall comply with AAMA CW 13.

7.0 SUBMITTALS:

(Refer Annexure 01 to 05 for formats and no. of copies)

7.1 SHOP DRAWINGS & METHOD STATEMENT:

- Submit preliminary shop drawings with Tender submission. Drawings shall show all major Curtain wall systems components. Submit samples of cruciform, glass, ACP and Al. Sheet etc. Tender will not be considered without preliminary Drawings, basic calculations and samples.
- Comprehensive, detailed and dimensioned shop drawings to indicate all set-out and construction details, adjacent work by others and for all proprietary products where required details are not indicated in the manufacturer's product data. Separate packages of shop drawings should be submitted without limitation for the following:
 - Building Envelope Test Prototypes
 - Glazing
 - Windows
 - Glass Railing
 - Louvers
 - Cladding
 - Skylights
 - Canopies, etc.

- The approval of shop drawings is for member sizes, surface treatment and the soundness of structural connections. Acceptance will not be given for any setting out or fabrication related issues. Furthermore, Acceptance and Endorsement in no way alleviates the Contractor from responsibility for errors or omissions.
- Shop Drawings & calculation submission shall be as per Annexure 02
- The successful bidder shall submit the system design drawings in line with tender drawing design intent complete with engineering calculations for all curtain wall elements.
- Time required for examination of shop drawings will be 15 working days for each submission, including re-submissions. The Contractor shall incorporate required changes due to inaccurate data or incomplete definition so that delivery and installation schedules are not affected. The Contractor's revision response time is not justification for delivery or installation delay of the contract works. Any re-submission shall include requested corrections and shall be responded to previous comments in point-by-point format.
- Prepare and submit shop drawing for the entire external façade system including plan, elevations, building section and construction detailing including interface details and submit to Architect & Consultant for review to the satisfaction of Architect and Façade Consultant.
- Manufacture should not commence until Acceptance and Endorsement has been obtained to use the relevant shop drawings. Packages of Shop Drawings shall, without limitation, include and indicate:
 - A drawing index sheet indicating all drawing numbers and full description of content. The drawings shall be clear, and all texts must be written in English.
 - General notes indicating: (1.) relevant codes and standards, (2.) project load conditions, acoustic requirements, and other performance criteria, (3.) material and structural properties and specifications for all metals, glass, silicone, etc., (4.) material properties and specifications for all other materials, insulation, etc., (5.) schedules of all hardware, (6.) schedules of fasteners, bolts, fixings, and anchors.
- Overall elevations and plans for entire building, indicating: (1.) Complete scope of works (2.) references to packages of details (3.) dimensions for PMC/Employer review (4.) largest critical dimensions of various components (5.) zones of wind loading (6.) numbering system for building envelope panels (7.) locations of Fire Access Panels (8.) locations of operable lights, doors and direction of opening.
- Set out of all work, including reference points, edge conditions and joint pattern, indicated on plans, elevations and sections as applicable.
- Tables showing full-size sections of all extrusions and structural members, including descriptions of structural properties, and specifications of materials.
- Framing, anchorage and fixings supported from base-structure, and embedment in the base structure, if required.
- Movement joints.
- Methods of assembly at all junctions, including sealing and fixing, indicated by three-dimensional and exploded views if requested.

- Method of installation, including but not limited to:
 - Erection tolerances.
 - Machined slots, keyholes and other methods for handling and connecting components.
 - Junctions and trim to base-structure and adjoining surfaces.
 - Fully dimensioned set-out drawings and templates.
 - All pre-tensioning and pre-stressing stages are required to meet the design criteria. (For Frameless Glass Walls.)
 - Access and materials handling equipment and requirements.
- Supporting Steelwork details including but not limited to the following:
 - Section sizes with accompanying steel grades
 - Grade of bolts
 - Types and positions of welds
 - Weld preparation requirements.
 - Cambers to steel sections
 - Locations and sizes of bleed holes in tubes
 - Cover plates.
 - Temporary cleats and lifting points, with load capacities.
 - Spider Fitting connection points (For Frameless Glass Walls)
- Glazing details, including but not limited to the following:
 - Glazing materials including sealants, gaskets, tapes, setting and spacer blocks.
 - Rebate depth and edge restraint.
 - Clearance and tolerance.
 - Methods of in-service glass replacement.
 - Hardware, fittings, and accessories.
- Method of draining the assembly, including details showing:
 - Pressure equalized drained joints.
 - Location, number and size of weepholes/slots.
 - Mechanical baffles to drainage outlets which are not pressure equalized.
- Methods of meeting performance criteria for thermal insulation, fire resistance, sound transmission loss and the like.
- Method of cleaning and maintenance in service.
- Panel details, including all joints and junctions, and support systems and panel stiffening.
- Connection details (including component parts, all information relevant to fabrication surface treatment, and erection) and provision of lightning protection.
- Shop drawings shall be in strict compliance with "prototype as tested" drawings which form part of the prototype testing procedure. No alterations are permitted to the shop drawings after Acceptance and Endorsement without written confirmation of the change from the PMC/Employer.
- Provide a complete numbering system and schedule for all cladding and glazing panels. Each panel shall be individually numbered in such a way that the manufacturing and installation history can be traced.

- Design and implement a permanent concealed marking system showing correct location and orientation when installed.
- Submit details for review and Acceptance.
- Indicate the location of each individual panel on shop drawings. Submit as-built elevations progressively indicating the location of each individual panel.
- **Installation Procedures Manual**
 - Submit a comprehensive manual containing all installation procedures, equipment and personnel required for acceptance prior to the commencement of installation works for review and Acceptance.
- **Operation and Maintenance Manuals**
 - The O&M Manual shall include, without limitation, recommendations for operating, and routine cleaning and maintenance, and all information required to ensure the full-service capability of the work, including source of replacement components, and methods of replacement of damaged components. The method of cleaning and timetable shall be specified together with cleaning agents which can and cannot be used.
 - The Operation and Maintenance Manual is to include the following documents:
 - ❖ Comprehensive list of all materials suppliers and agents.
 - ❖ Sealant and Gasket Information – All brands.
 - ❖ Finishes information – coating system type colour, supplier.
 - ❖ Defective works log to be kept up to date for the duration of the warranty period outlining each defect type location and corrective action to rectify each defect.
 - ❖ All Warranties from suppliers and Contracting Parties.
 - ❖ As-built drawings (AutoCAD Files and A3 hard copy).
- **As-Built Record Documents**
 - Prepare as-built drawings, photographs and other records progressively as the work proceeds. Submit progress reports on monthly intervals and provide complete as-built documentation at Completion of contract works. As-built drawings shall be submitted to the PMC/Employer for necessary onward submission to the relevant Regulatory Authorities for endorsement. These drawings should have been updated to reflect all construction-related modifications to the original drawings. This set of drawings shall be indexed and bound.
 - Submission of design engineering and Shop Drawings to the satisfaction of consultant and taking final approval from the Consultant / Architect shall be façade contractor's responsibility.
 - Hardware accessories details are also included in the shop drawings.

7.2 VISUAL MOCK-UP SUBMISSIONS

- The Contractor shall install a full-scale mockup for typical elevation treatment at locations to be confirmed by the Employer's representative / client.
- The visual mock-up for the glazing assembly will be required to be Accepted and Endorsed with respect to appearance of colour.

7.3 PERFORMANCE PROTOTYPE & PROTOTYPE TRIAL ASSEMBLIES SUBMISSIONS

- Refer to Annexure 3 for types and systems that require performance prototype for testing.
- Submit (within one month of the approval of relevant sample submissions prototype samples for review, and installations for testing, as follows:
- Detail Prototype Trial Assemblies of mullion/transom junctions (full-size, 600 x 600 mm): Trial assemblies shall include a typical 4-way stack joint, a typical interface at ceiling level, and atypical vent panel. The assemblies should include all components such as baffles, gaskets, seals, fixings, sponge blocks, sleeves, trims, etc. These assemblies shall be complete and shall not be limited by this list. Test assemblies shall be submitted for review, Acceptance and Endorsement prior to erection of any Performance Prototypes.

7.4 STRUCTURAL CALCULATIONS

- Submit for review, structural computations of all the critical elements that constitute the Curtain wall, railing, cladding, canopy, skylight, louvers, MS supporting structure etc. Comply with given design criteria and loads following the given standards. Include analysis for design wind pressure, dead loads, thermal stresses and seismic loads for all elements in the load path.
- The submission of calculation shall include the checks as per load path Annexure 2.

7.5 SUBMITTAL PROCEDURE:

- As per the decided protocol, submit preliminary shop drawings as project proposal by the successful bidder to consultant / Architect's review.
- Incorporate consultant / Architect Review comments related to the preliminary shop drawings, in the final shop drawings for approval.
- Submit glass Analysis, glass manufacturer's wind pressure analysis and thermal analysis showing that the specified maximum deflections and probabilities of breakage are not exceeded.
- Submit thermal analysis for the framing system for the U value of framing as per ECBC requirements.
- Submit results of silicone Adhesion Tests for records. Sealant manufacturer's test report for weather seal silicone adhesion to all relevant substrates. The test must include a seven-day water immersion after which silicone must have excellent adhesion to substrate. Report adhesion strength in terms of shear stress and tensile stress. Test samples shall approximate sealant joint sizes and configurations intended for production materials.
- Submit a letter of certification from the sealant manufacturer stating that the sealant has been tested for adhesion and compatibility on production samples of metals, Granite, glass, and other glazing components and that all sealant details and application procedures shown on the reviewed shop drawings are acceptable for use. If required specifically the following submittals shall be provided by the contractor.
- Sealant Manufacturer review of the Mockup Drawings prior to the mockup.

- Test results for all job specific concealed and exposed sealant conditions confirming compatibility are mandatory for all material prior to mock-up and testing. Preliminary results in advance of the final report will be acceptable.
- Complete instructions for handling, storage, priming, installation, curing and protection of each type of sealant, joint filler and accessory.
- Manufacturer's Data sheets, clearly indicating shelf life of sealant to be supplied.
- Manufacturer review of the final drawings clearly indicating that each product furnished complies, with this specification is recommended for the application shown, and compatible with each other materials in the joint system.
- Quality assurance sample for the curtain wall. Submit weekly Quality Assurance Documentation.
- Manufacturer's warranty at job completion.
- Chart of required submittal pertaining to sealant.

Completion	Pre mockup	Post mockup	During Fabrication
Sealant Manufacturer Print Review	X		
Sealant Material Data Sheets	X		
Manufacturers Installation	X		
Instructions	X	X	X
Compatibility Testing Report	X		
Final Shop Drawing Review		X	
QA Sample Logs		X	
Shop QA Logs			X
Sealant Performance Warranty			X

8.0 SAMPLES:

The Bidder shall submit the following samples along with bid submission for review:

- 8.1** Submit the following items representative samples of products and materials, including finishes and representative factory-fabrications and site-installed assemblies. Samples to be typically 300mm x 300mm. Include minimum 3 samples without limitation for each of the following:
- Metal types and finishes, including proposed finished shapes, sections and extrusions. Provide metallurgical analysis certificates for alloy and temper of metal components.
 - Glass types and finishes indicating colour, surface pattern or texture, finish, surface coatings, and the range of variation, if any.

- Colour samples of pre-finished production material showing the limits of the range of variation in the selected colour.
 - Check samples to confirm or match PMC/Employer 's sample.
 - Preliminary finishes control samples.
 - Final finishes control samples.
 - Colour samples for all sealants, gaskets, and accessories.
- Joint system components, including sealants, gaskets, interlayer, rain-screens, baffles, flashings, elastomeric sealants, backing rods, etc., with details of compatibility with silicone and polyurethane based sealants, and all extruded gaskets, interlayer's, sealants, tapes and fixings.
- Typical fabrications and assemblies, showing welds and grinding, screwed and bolted junctions, fastenings and workmanship.
- Fixing and accessory items:
 - Bolts, nuts, washers, screws, pins and rivets (with all grades indicated)
 - Proprietary hardware
- Miscellaneous materials:
 - Insulating material.
 - Backing material.
 - Interlayer.
 - Lightning protection tabs.
 - Panel materials for spandrels and other non-vision areas.
- Examples of repairs and making good to typical range of in-service damage to finishes, including chips, cracks and scratching.
- Additional samples for testing sealants and finish coatings as required.
- A range of colour samples of pre-finished materials samples material showing the limits of the range of variation in the selected colour.

8.2 Employer/Architect reserves the right to ask for samples which show the fabrication techniques and workmanship of the component's parts, accessories and other exposed auxiliary items, before fabrication of this work proceeds.

9.0 FABRICATION:

- 9.1** Complete fabrication shall be done at the factory with a competent workforce thoroughly skilled in their trade. The fabrication shall follow the procedure manual and sequence. Before the critical assemblies are carried out the inspection of components shall be completed including cleaning of panels in no access area.
- 9.2** Assemblies shall be neat and free of defects that impair strength, function or appearance. The work shall be accomplished in compliance with the specified criteria without buckling, opening of joints, undue stress on fasteners, sealants and gaskets, opening of welds, cracking or chipping of glass, leakage, noises and other harmful effects. Complete production shall be done in the factory.
- 9.3** All exposed work shall be carefully matched to produce continuity of line and design. All joints in exposed metal work, unless otherwise shown or specified, shall be accurately fitted and rigidly secured with joint sizes conforming to industry standards. The movable frames like openable vent shutters shall need to be crimped at the corner for better strength and aesthetics.

- 9.4 Except where otherwise shown, specified or directed, the method of assembly and joining shall be the Contractor's option provided the results are satisfactory. The manufacturer's proven methods that will produce the required standards of workmanship shall be used subject to approval. Fabricate and fasten metal work so that the work will not be distorted, nor the fasteners overstressed from the expansion and contraction of the metal.
- 9.5 All welding shall be in accordance with the appropriate recommendations of the American Welding society and shall be done with electrodes and/or by methods recommended by the manufacturer of the alloys being welded. All welds behind finished surfaces shall be carefully done as to minimize distortion and discoloration on the finished side Unless otherwise shown or specified, all weld beads or expose surfaces shall be ground and finished to match and blend with finish on adjacent parent metal. The grinding and polishing of nonferrous metal shall be done only with clean wheels and compounds free from iron and iron compounds. No soldering and/or brazing shall be allowed.
- 9.6 Use concealed fasteners in visible finished work.
- 9.7 All Composite aluminum panels shall be factory fabricated in compliance with the manufacturer's Data sheets. All panels shall be cut and routed using equipment and tools recommended and approved by the panel manufacturer.
- 9.8 A complete method statement shall be submitted by the contractors.
- 9.9 All the Glazing units shall be air and watertight.

10.0 PRODUCT HANDLING & STORAGE

- 10.1 Package and store materials in a manner that will prevent surface damage or contamination distortion breakage or structural weakening.
- 10.2 The material shall be packed and dispatched properly without any damage to the finish, glass or joints. Proper cushioning is to be provided to avoid rubbing with each other.
- 10.3 A proper stacking arrangement at site to ensure no damage to the finish and the finished product takes place. Storage plan shall be presented and approved before the material arrives at site.
- 10.4 The factory applied protective peel-off foil shall only be removed after the panels have been installed on site. Replace damaged panels if any after peeling off protective foil.
- 10.5 Replace any material damaged during manufacture, shipping, storage or erection.
- 10.6 Protect materials in place from contamination and damage.
- 10.7 Protect factory applied finishes from staining and scratches.
- 10.8 Sealants to project site in manufacturer's original unopened containers with manufacturers name, product name, and color fully indicated thereon. Store in accordance with manufacturer's instruction.

11.0 INSPECTION

- 11.1 All shop and field materials and workmanship shall be subject to review by Employer/Architect at all times. Such reviews shall not relieve the Contractor from the obligation to provide materials conforming to all requirements of the Contractor Documents and matching approved samples. The Contractor shall promptly

correct any deficiencies reported and carry out his own control measurements for all materials, whether reviewed or not.

11.2 Verify that surfaces and conditions are situated to receive the work of this Section at site, and that conditions will not adversely affect the installation and performance of the installed work.

11.3 Correct all unsatisfactory conditions prior to beginning erection of specified work.

12.0 INSTALLATION

12.1 GENERAL

- Erection shall commence only as per written procedure. Bracket layout shall be checked properly by accurate instruments before grid fixation to start.
- Erect Grid system in accordance with the approved Shop Drawings.
- Provide competent workmen, materials lifting machines, tools & accessories and supervision necessary to erect the complete material.
- Do not install components which are defective in any way, including warped, bowed, dented, abraded, and broken members and glass with edge /surface damage.
- Remove and replace all damaged components to Architect's Satisfaction.
- The initial installed panel to be checked for plumb line level and using fixtures for maintaining line levels.
- Set walls plumb, squareness, level and fasten securely to correctly verify horizontal alignment. Seal joint within wall and between adjacent constructions.
- Do not cut, trim or weld components during erection in any manner, which would damage the finish, decrease strength, or results in a visual imperfection or failure of such components. Return components that require alteration to the shop for re-fabrication, or for the replacement with new parts or components.
- Install components level, plumb, true to line, and with uniform joints and reveal. Attach the structure with non-staining and non-corrosive anchors, fasteners, spacers, and fillers as required.

12.2 TOLERANCES:

- Tolerances for building frame and other work are specified in other Sections. Make provisions for these tolerances, including a ± 30 mm concrete slab tolerance.
- All parts of the work when completed shall be within the following tolerances:
 - Deviation from plumb, level or dimensioned angle shall not exceed 2 mm per 3.2 of length of any member, or 3mm in any total run in any line.
 - Deviation from theoretical position in plan or elevation, including deviation from plumb level or dimensioned angle, shall not exceed 5 mm total at any location. Change in deviation shall not exceed 2mm for any 3.2m in any direction.
 - Maximum offset from true alignment between two consecutive members placed end to end shall not exceed 1.5mm.
- The maximum offset between glass framing members at corners of glazing pocket shall not exceed 1mm.

- Provide accurate benchmarks for use in wall erection on all floors. Promptly correct any errors or inconsistencies.

12.3 ASSEMBLY AND ANCHORAGE:

- Anchor components/ parts securely in place by bolting, welding or other permanent mechanical attachment system, which will comply with performance requirements and permit movements which are intended or necessary. Install slip pads between moving parts.
- Provide a separator at contact surface of dissimilar material Whenever there is a possibility of corrosive or electrolytic action.
- Remove weld slag and apply prime paint over welds. Also paint exposed portions of inserts. Touch up shop applied paint that is damaged by welding.
- Complete method statement shall be submitted (Building wise)
- Ensure that no loads from, due to or generated by the base-structure are transferred to the cladding system, including loads resulting from short-term or long-term structural deflection or shortening of slabs or beams. It shall be transferred to the base building.

12.4 SITE MODIFICATIONS

- Finished work which contains unauthorized site modifications or work not in accordance with the Accepted shop drawings, may be required to be removed and replaced.
- Unauthorized work may be Accepted subject to additional computations and testing at the Contractor's sole discretion. If requested, carry out and pay for all such testing, and submit all computations, test results and any other information required.

12.5 STAGED COMPLETION

- Cladding shall be installed in an orderly sequence. Where practical, cladding shall be completed and closed off on a floor-by-floor basis.
- Provide temporary flashings at completion of each stage to waterproof and weatherproof the enclosed work. Remove temporary flashing before proceeding with subsequent work.
- Sections of cladding which are left open for any reason shall be designed in accordance with the design wind serviceability load with an allowance for wind funneling through the base-structure.

12.6 TEMPORARY MARKING:

- Provide temporary marking of glass (if necessary). Use a soluble marking compound and remove all traces on completion. Do not use lime or advertising stickers.

12.7 GLAZING:

- All glass processing shall be under controlled condition. Mock-up glass shall not be used on the building. Glass shall be of the specified types and quality,

with seamed edges and corners. Inspects all lights of glass before installation. Do not install defective glass.

- Before setting glass, inspect frame for proper dimensions and squareness. Adjust frame and/or glass size as required to meet specified requirements. Use fixtures to keep the frame in true squareness.
- Except as otherwise specified, comply with FGMA Glazing Manual. Provide a minimum nominal glass bite of 15mm where glass bite will be reduced by frame thermal movements increase nominal glass bite to provide 12mm bite when splice joints are fully opened.
- Thoroughly clean glazing pocket before setting glass. Solvents shall be compatible with aluminum, glass and glazing materials. Place glass support blocks at end points as per guidelines.
- Details of installation shall permit replacement of glass after the construction period.
- Replace any glass, which breaks or sustains edge damage, surface damage or damages to reflective coating as defined above.
- Experience of glaziers and logbooks:
 - Glazing shall be carried out by experienced personnel who have pre-qualified for the type of work undertaken. All work shall be supervised by an Accepted glazing supervisor.
 - Details and experience of each glazier shall be recorded in the logbook. Samples of each glazier's work shall be periodically removed for testing.
 - Maintain a glazing logbook on a daily basis for all glazing and submit progressively. The glazing logbook shall be available for inspection at any time without notice.
 - As a minimum the logbook shall contain:
 - ❖ Date.
 - ❖ Name of glazier.
 - ❖ Individual panel numbers glazed / intended location of installed work.
 - ❖ Sealant manufacturer and type, colour and batch number.
 - ❖ Daily air temperature inside and outside the factory.
 - ❖ Tape and accessory manufacturers and types.
 - ❖ Test results, including "skin over", "de-glaze", and "hand pull" results, as applicable.
 - ❖ Glazing supervisor's verification.

12.8 SEALANT APPLICATION:

- Apply sealant materials in accordance with sealant manufacturer's recommendations.
- Apply sealant using a continuous bead of sealant.
- Apply a continuous sealant bead between flashing and adjacent construction.
- Before applying sealant, examine the substrates, adjoining construction and the conditions under which the work is to be installed. Do not proceed with the work until unsatisfactory conditions have been corrected. In no instance shall the installer install sealant in conditions which conflict with this specification without approval.

- Clean bonding joint surfaces to remove dirt substances, which might interfere with bond or otherwise impair the work. Do not apply elastomeric sealants to joint surfaces previously painted or treated with sealer or curing compound or other coatings, unless a laboratory adhesion and peel test in accordance with ASTM C 920 and ASTM C794 has been performed and successfully demonstrated that bond will be durable.
- Unless otherwise shown or specified and documented, install materials in accordance with the manufacturer's printed instructions.
- Confine sealants and primers to joints using masking tapes or other precautions where required to prevent contact of sealant or primer with adjoining surfaces which otherwise would be permanently stained or damaged by such contractor by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing sealant.
- Where joint filler is used as backup for sealant, install filler continuously without voids or interruptions to depth and shape specified by sealant manufacturer for proper application and performance of product.
- Install bond breaker in joints as shown and wherever recommended by the sealant manufacturer to prevent bond of the sealant to surfaces where such bond might impair the performance of the sealant. Do not puncture the surface or skin of expanded polyethylene joint filler backer rods.
- Apply joint fillers accurately according to the joint profile shown in the drawings after joint cleaning and priming. Provide watertight and airtight corners and joints in a manner recommended by the manufacturer.
- Apply sealants in continuous beds filling joint from the bottom without openings, voids or air pockets so as to provide a watertight and airtight seal for the entire joint length.
- Apply elastomeric sealants, in field joints not subject to traffic or other abrasion to a depth equal to 50% of the joint width, but not less than 6mm and not more than 12mm.
- Immediately after sealant application and prior to time skinning or curing begins, tool sealants for smooth, uniform beads, to eliminate air pockets and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealant from surfaces adjacent to joint. Do not
- use tooling agents which discolor sealants or adjacent surfaces or are not approved by sealant manufacturer. Tool exposed surfaces of sealants to the profiles if not shown, tool slightly concave to match the configuration as in ASTM C1193.
- Provide a slight slope on horizontal joints where horizontal and vertical surfaces meet.
- Remove excess sealant promptly as the work progresses and clean the adjoining surfaces as may be necessary to eliminate any evidence of spillage.
- Do not proceed with installation of field sealants during inclement weather. Do not proceed with application of sealants when heavy wind loads are forecast during the period it required for initial or nominal cure of sealants, whenever possible, schedule the application and cure of elastomeric sealants during periods of mean temperatures. Install field sealants in accordance with

manufacturer recommendation to reduce sealant Wrinkling from movements during cure. Do not install sealants into joint widths that are less than specified without approval of the employer/Architect.

12.9 LOGBOOKS

- Maintain and submit progressively logbooks for all sealant installation.
- Include quality assurance records, indicating Standards and Codes of Practice, test procedures, acceptance criteria and pass/fail rate.
- Details and experience of each applicator shall be recorded in the logbook. Samples of each applicator's work shall be periodically removed for testing.
- The sealant logbook shall be available for inspection at any time without notice.

12.10 CURING

- Provide for the appropriate cure conditions, in accordance with the sealant manufacturer's written recommendations at factory and on-site. Protect external sealants from inclement weather until fully cured.
- Cure sealants in compliance with manufacturer's recommendations, to obtain high early bond strength, internal cohesive strength and surface durability.
- Submit details of procedures required for cure and protection of joint sealers during construction period to prevent deterioration or damage (other than normal wear and weathering).
- Do not relocate sealed components within the factory or on-site, until the joint has developed sufficient bond strength and cohesive integrity.
- Install sealants to interior at the same time using the same or compatible materials as the exterior sealants.
- Supply glazing unit's factory pre-glazed in accordance with BS952 or AS1288. No site glazing or re-glazing shall take place unless accepted in writing.

13.0 PROTECTION:

- Take all necessary means to prevent any damage (scratches, dents, nicked edges etc.) to components during handling and erection Replace components beyond acceptable field repair at no additional cost to the Employer/Architect. Special protection tape of 70 microns shall be applied on to the profiles. The tape glue should not get transferred on to the profile surface or react with the finish till hand over time. Sample of the final finish of profile and protection tape shall be submitted for approval before production starts.
- Protect glass surfaces with a protection sheet. Do not apply markers of any kind to glass surfaces.
- Remove and replace glass which is broken, chipped, cracked, abraded or damaged in any manner as a result of construction activities, natural causes of accidents or vandalism. Replace with new material at no additional cost to the Employer/Architect
- Maintain glass in a clean condition at all times, including during construction to prevent glass damage from corrosive action from the elements and contributing side-effects (by wash off) to the components and other work.
- Complete method statement shall be submitted by the contractor

- Adjacent work by others
- At the completion of all adjacent work by others, including services work, attend the Site, inspect the work areas generally, and repair all damage, complete or make good finishing, trimming and sealing, and replace any damaged or dislodged work.

14.0 CLEANING & MAINTENANCE:

- Clean surfaces as required to remove corrosive substances. At the conclusion of construction, clean all surfaces to the satisfaction of Architect.
- Provide written cleaning procedure and cleaning agents which are compatible with aluminum, glass, glazing materials and sealants.
- Periodically removes from the site debris, excess materials are unused tools and equipment resulting from this work. At the conclusion of construction, leave the premises in a clean condition acceptable to Architect.
- The complete method statement shall be submitted by the facade contractor.

15.0 GUARANTEE:

- Submit written Guarantee agreeing to repair or replace defective materials and workmanship during the guarantee and defects liability period. Defective materials and workmanship include, and is not limited to the following
 - Abnormal deterioration
 - Aging or weathering of the work
 - Water leakage
 - Air leakages exceeding specified limits.
 - Structural failure of components resulting from exposure to pressures and forces up to specified limits.
 - Failure of operating parts to function normally Deterioration or discoloration of finishes in excess of normal weathering and aging.
 - Glass breakage, secondary glass damage or breakage due to falling glass fragments, deterioration of glass reflective coating.
 - Scratching denting other type of surface damage to the composite aluminum panels.
 - Silicone sealant failure to the work to fulfill other specified performance requirements.
 - PVDF/ SDF finish on Aluminum works.
- The Guarantee does not include damage caused by vandalism or natural conditions exceeding the performance requirements. This Guarantee and its enforcement shall not deprive the Employer/Architect of other action, Right or remedy available to him.
- **General Guarantee:**
 - The general Guarantee for the systems and for the performance of the materials used in the systems shall be provided for a period of ten (10) years after the date of final acceptance / virtual completion of the project (Excluding the Defect Liability period) This Guarantee shall include the following special Guarantee from the manufacturer /suppliers also.

- The Guarantee period for peeling or deterioration of glass reflective coating shall be for ten (10) year period after the date of final acceptance / virtual completion of the project.
- The Guarantee for Aluminum composite panel shall be provided for a period of 10 years after the date of final acceptance / virtual completion of the project.
- The Guarantee period of sealant shall be 15 (fifteen) years after the date of final acceptance /virtual completion of the project.

16.0 PROFORMA FOR GUARANTEE:

- The Contractor shall furnish performance Guarantee for the entire external façade systems for a period specified above from the date of completion of work. The Guarantee shall be in legal paper in acceptable form. The performance Guarantee shall cover for replacement if any or all members and components involved in the above systems by the contractor at his own cost in case if any deficiency or failure in performance of the Aluminum work as per the design requirements during the Guarantee period. The contractor has to undertake responsibility for safety with respect to set out of glass with or without member with which it is held in position during the Guarantee period.

17.0 SPARES (ATTIC STOCK)

- Submit certification that all spares will be available off-the-shelf, or with a lead time not exceeding 4 weeks from date of order, for the warranty period.
- Provide the name and address of all suppliers and manufacturers.
- Spare glass shall not be used for glass breakage replacements as may be required during the course of installation or the Defects Liability Period.
- All spares shall be new, protected in Accepted wrapping with identifying labels.
- Deliver the spares at the completion of the work as per owner's direction as and when required.
- Formally hand over and submit complete schedule of types and quantities, including full replacement instructions, and any special tools required.
- Required spares shall include:
 - 1 replacement glass panel for every 50 panels used in the building.
 - Quantities are to be proportioned according to the glass sizes that are used. (Curtain Wall)
 - 1.5% panels maximum of each Cladding panel type and size.
 - 5.0% of painted aluminum band rails/Louvers/windows if any
 - 1.0% of hardware, stays, hinges etc. for all louvers/ windows if any.
 - ``All percentages are based on actual installed quantities of each type.
 - All the dies used to extrude the sections on this project shall be available for the warranty period.

18.0 MODE OF MEASUREMENT:

- Unless noted otherwise in the Bills of Quantities, terms will be measured generally in accordance with IS 1200 – Part 14 (Clause 3.0)

19.0 RESPONSE TIME:

- Façade vendor shall resolve the Nonconformance raised by the Client / PMC / Architect / Façade consultant within the given time frame. But not later than 2 weeks.

20.0 SAFETY:

- First aid appliances including adequate supply of sterilized dressings and cotton wool shall be kept in a readily accessible place.
- An injured person shall be taken to a public/private hospital without loss of time, in cases where the injury necessitates hospitalization.
- Suitable and strong scaffolds should be provided for workmen for all works that cannot safely be done from ground.
- No portable single ladder shall be over 8 meters in length. The width between the side rails shall not be less than 30 cm. (clear) and the distance between two adjacent rungs shall not be more than 30 cm. When a ladder is used an extra mason shall be engaged for holding the ladder.
- The excavated material shall not be placed within 1.5 meters of the edge of the trench or half of the depths of trench whichever is more. All trenches and excavations shall be provided with necessary fencing and lighting.
- Every opening in the floor of a building or a working platform shall be provided with suitable means to prevent the fall of persons or materials by providing suitable fencing or railing whose minimum height shall be one meter.
- No floor, roof or other part of the structure shall be so overloaded with debris or materials as to render it unsafe.
- Those engaged in welding works shall be provided with welder's protective eye-shields and gloves.
- Fire Extinguisher minimum 2 numbers to be provided by contractor at the period of execution of the site.
- No paint containing lead or lead products shall be used except in the form of paste or readymade paint. Suitable facemasks shall be supplied for use to the workers when the paint is applied in the form of spray or surface having lead paint dry rubbed and scrapped.
- The Contractor to the painters shall supply overalls and adequate facilities shall be provided to enable the working painters to wash during the periods of cessation of work.
- Hoisting machines and tackle used in the works, including their attachments, anchorage and supports shall be in perfect condition.
- The ropes used in hoisting or lowering materials or as a means of suspension shall be of durable quality and adequate strength and free from defects as approved by an authorized third-party agency.
- Those engaged in working at heights shall use proper safety harnesses.
- Provide fully toughened glass on the inner side of the IGU if glass is abutting with floor.
- The contractor to observe and follow the safety norms as per the safety handbook provided by the client

21.0 ITEMS TO BE CO-ORDINATED:

General:

- The Contractor shall initiate and manage the design, development, coordination, installation and testing of the interface between other trades, services and systems carried out on site.
- The following is a list detailing the trades that are to be considered.
- However, the scope of interfacing required by the Contractor shall not be limited by this list.
 - All building Mechanical and Electrical systems (HVAC, Hydraulic, Electrical, Lighting, PA, IT Systems, Communication systems, Security systems, BMS)
 - Internal partitions, balustrades and wall finishes
 - Internal floor finishes including raised floors
 - Internal suspended ceilings and other ceiling finishes
 - Building Maintenance Units (BMU)
 - All integrated, non-integrated, illuminated and non-illuminated signage and other information display systems.
 - External paving and landscaping
 - All roofing and weather proofing works
 - Building Civil works.
 - Façade Signage
 - Roofing
 - Lightening arrestor

Drainage:

- All materials, design and installation necessary for the drainage of all cladding systems shall be provided by the contractor.
- The design of system drainage shall be coordinated with the works of the PHE (Public Health Engineering) contractor where necessary. Connection of external gutters and flashed areas to drainage pipes shall be by the PHE contractor.

Lighting:

- Design of Lighting which is integral to or interfaces with any of the cladding systems shall be fully coordinated with the Electrical / Lighting contractor. All openings around conduits in the building envelope system shall be properly designed, coordinated and sealed.

Security Services and Fire Services:

- All Security Systems and Fire Services which interface with the external cladding systems including locking mechanisms, intercoms, PA systems, CCTV's, fire services inlet cabinets, fire service control panels, and so forth shall be incorporated into the design of the cladding systems where necessary.
- This shall include provision of openings, lockable hinged panels with glazed in-fill lights where required, concealed conduits and appropriate ironmongery as is necessary. All E/M equipment shall be provided and installed by the E/M contractor.

- The Contractor shall rigorously coordinate the technical requirements of the E/M contractor and the aesthetic requirements of the Contractor.
- Where there is uncertainty regarding location or extent of coordinated works, the Contractor shall be consulted, and Acceptance received before any required fabrication of the building envelope works may precede.
- Signage and Information Display Systems:
- Signage Boxes and Information Display Systems shall be fitted with a hinged heat strengthened glass cover that allows the inside and outside of the glass to be cleaned and the lights to be replaced.
- For Information Display Systems of a larger scale the Manufacturer's installation and maintenance requirements shall be complied with.
- A Manufacturer's certificate of compliance shall be submitted by the contractor upon completion of the works. All work shall be closely coordinated between the Lighting contractor and the Facade Contractor.

22.0 DRAFT GUARANTEE AND INDEMNIFICATION:

GUARANTEE DRAFT FOR EXTERNAL GLAZING SYSTEM

- The Guarantee confirms that the installed Façade Products have been designed, tested, fabricated and installed to the specification as set out in the contract tender document and is in line with international standards and correct practices. The installed products will perform as per the performance criteria given in the specification for a minimum of 10 (TEN) years after the defect liability period.
- The Guarantee covers design defects, material defects & workmanship defects for a period of 10 years.
- Any nonconformance found during the Guarantee period shall be corrected or replacement carried out only after the correction and replacement is agreed by the Engineer-in-charge or client's authorized representative.
- A back-to-back product guarantee shall be handed over to the Engineer-in-charge or client's authorized representative.

INDEMNIFICATION

- Façade Contractor shall be liable for and shall indemnify V3 Façade Design Studio, its Partners, employees, agents & Client ('Indemnified Party') and to keep the Indemnified Party indemnified against each and every liability which the Indemnified Party may incur to any person whomsoever and against any claims, demands, proceedings, damages, costs (including, but without limitation, reasonable legal and experts' costs) and/or expenses sustained, incurred or payable by the Indemnified Party whatsoever and howsoever arising out of or in connection with this tender, except to the extent that such claim shall have been caused by any act, omission or contribution of the Indemnified Party.

23.0 PREAMBLE TO BILL OF QUANTITIES

Unless otherwise specified rate quoted for External Glazing works shall include the following: -

- Design, supply, cost of all materials, labor, equipment, tools & plant required, conveyance, infrastructure facilities, single / double – Scaffolding, staging, formwork, working platform, suspension platforms, davits, hosting equipment, protective materials etc. as required at any stage of execution / maintenance.
- Work at all levels, heights & elevation and location.
- Items should strictly comply with the drawings, technical specification and bills of quantities. Specifications and drawings furnished herewith will only be the governing factor for the bidders to choose the system and materials as per design intent.
- Entire glazing with system including type & thickness of glass, extruded frames, sleeves, inserts, gasket, adhesive tapes, sealant, supporting arrangements including fastening and anchoring system envisaged in the bills of quantities is only indicative and is meant to set out a general outline of the proprietary system as commonly understood. Since the curtain wall glazing system, both in items of design, materials, details, methodology of execution are proprietary in nature, the onus of the design, drawings specifications and execution satisfying design intent, performance requirements and site conditions lies solely on the bidder.
- Bidder shall be responsible to design the system as per the sizes and shapes of the panels shown in the drawings including any modifications as may be required during execution and the designed system should withstand the wind pressure specified in the documents as well as all other incidental forces and stresses likely to be experienced under service conditions, i.e. dead weight, thermal expansion due to building movement both vertical and horizontal etc. Bidder shall also be responsible to design the entire aluminum framing system, type & thickness of glass considering the minimal spectral and physical parameters of the glass set out in the technical specifications and bills of quantities, sealant including bite thickness, supporting arrangements including fastening device size & material, preparation of shop drawing in two stages namely project proposal stage and execution stage, fabrication, supply, erection of the system and testing the system as envisaged in the technical specification and bills of quantities i.e. for both mock-up & field test.
- Bidders note that the eventual requirement is performance oriented within the profile, to achieve total glazing unitized / semi-unitized system specified in the bills of quantities expected from the design that is adopted. i.e. resistance to design wind pressure, prevention of air & water penetration, continuous pressure equalization system, built-in-continuous internal drainage for condensation & penetration & built-in adjustability for thermal movement, thermal barrier, separator gaskets for bi-metallic correction, smoke seals wherever essential etc.
- The bidder shall be responsible for designing the framing system to support both vision & spandrel panel on a continuous framing system. Bidder shall be responsible to provide a full-scale mock-up at site for at least 2 bay (Vision and Spandrel panel) and for 2 storied prior to commencement of fabrication based

on approved project proposal in such a way, the system provides aluminum member, glass, Aluminum metal Panel, EPDM, Sleeve details in the system for expansion, pressure equalization concept and in-built drainage system, details of drain point etc.

- Bidder shall be responsible for incorporating the air pressure equalization principal with Concealed continuous gutter at all levels and at all Floors for self-drainage to achieve water tightness besides providing air & water barrier with Gaskets. Barrier should be at minimum three stage Curtain wall system. Entire system shall be designed to accommodate thermal movement of the aluminum components and glass resulting from the exterior ambient temperature from 15 to 45 deg. Celsius and to accommodate vertical movement of maximum 10 mm between floor elements conforming that no aluminum members shall be visible from outside.
- Bidders to note that the quoted rate for the items covered External glazing works shall include all the applicable items envisaged in the System, whether not they been specifically described in the documents/information supplied, including charge in thickness of members as appropriate.
- Bidders note that the minimum spectral parameters of Glass, Technical characteristics of Aluminum composite panel, technical properties of the sealant given in the Annexure to Bills of quantities technical specifications shall be strictly complied with.
- Bidder shall be responsible for designing the system in such a way they the sealants shall withstand movement up to 50% or to the limitation of manufacturer's specification. Exposed sealant surface shall not crack on bubble. No acetify sealant shall be used. Electrometric sealant shall not be allowed to use, unless otherwise the sealant manufacturer renders the service on product back-up and guarantee.
- Bidder shall produce design parameters of the following components in 2 stages namely, Project proposal stage in line with bid submission and shop drawing based on the system Approval, but not limited to,
 - Glass
 - Sealants
 - Aluminum members
 - Fasteners
 - Brackets
 - Separators, Anchors.
- Aluminum extrusions shall be of aluminum alloy 6063 – T5/T6 conforming to BS 1475.
- Aluminum composite panels shall be fire rated grade Class B of Aluminum Alloy 3105 – H14 or 3003 – H14
- ACP thickness of panel shall be 4mm, (skin aluminum on both sides should not be less than 0.5mm) suitably stiffened internally on the back side (Methodology of fixing the stiffener to be described by the Bidder for approval) for preventing deflection due to design wind pressure beyond permissible limits.
- In general, the proposed glass shall be approved make and as specified in the document. The double-glazing unit shall be supplied by the approved

processor. Only new substrate glass shall be used for coating and to ensure the same, the manufacturer shall produce the certificate.

- Float glass shall conform to ASTM C 1036.
- Heat strengthened and tempered glass shall conform to ASTM C 1048
- Tempered glass shall conform to ANSI Z 97
- The glass shall be designed to satisfy the requirements of AS 1288.
- All safe glass shall conform to the requirements of AS2208 or CPSE 16 and CFR 1201.
- In general, the glass products shall conform to the following international standards.
 - BS 952 – Part I
 - ASTM C 1036 – 91
 - EN 572 – 1 & EN 572 – 2
 - NBN S 23 – 002
 - NF P 78 – 302
 - DIN 1249 TEIL 3
 - NEM 3264
- Weather Gaskets shall be EPDM micro cured of Amee Rubber make or equivalent with shore 60 & 65 EP / TN. Structurally glazed glass shall have silicone gasket covering the edge of the glass.
- Baker rods shall be polyurethane foam of “supreme of approved equivalent make”. Spacer tape (Adhesive tape) shall be of open cell polyurethane foam.
- Secondary sealant, primary sealant, spacer, setting blocks made of solid extruded silicon rubber with a hardness of 85 Durometer – Shore A shall be provided.
- All supported brackets for aluminum members in the structural glazing shall be 6005 – T6 – structural grade and the brackets to have serrations.
- All washers and all other fastening materials supporting system, such as brackets and similar attachments used for fixing & erection of the aluminum members, aluminum composite panel shall be of hot dip galvanized steel.
- All flashings / smoke seals / fire stops shall be provided to all floor levels, skill and to proof parapet at terrace and slides of vertical surfaces where necessary.
- All bolted connections shall include lock washers, lock nuts or other locking device and conceal the fasteners here visible in the finished work. Fasteners at non-wetting locations shall be cadmium plated, if directed.
- All hot dip galvanized steel shall conform to ASTM A 123.
- All electro galvanized steel shall conform to ASTM A 164 or FS-Q-Z-325b (2).
- All stainless steel shall be 316 grades, brush finish and 300 series non-magnetic steel.
- Where finishes are not specified all such metals shall be finished in a manner consistent with similar and necessary to conform to the design intent.
- Shop Drawing for Mock-up as well as for entire external glazing system based on approval Design Parameters shall be provided for approval, in two stages as described elsewhere.
- Structural test shall confirm to ASTM E 330

- Mock-up test and Field test shall be carried out accordance with technical specification including all material required for Mock-up test and Field test. Full scale mockup testing is mandatory and is governing parameter for performance verification.
- Conducting mockup test including necessary arrangements at FITI laboratory with the design wind pressure. If the Mock-up test fails, correct the defects revealed till the satisfaction of the performance data as set out in the technical specification.
- Conducting Field test including necessary arrangements scaffolding hose, water & manpower. If the field test fails, correct the defects revealed till the satisfaction of the performance data.
- Aluminum Extrusions, Glass, Aluminum composite panel or Aluminum solid panel, Gasket, sealant supposing system including fastening devices provided at site shall be in line with approved Mock-up and shall be identical.
- Samples of all components such as aluminum Extrusions (Main manners, supporting member, sleeve member etc.) Glass, Sealants, aluminum composite panel etc. shall be submitted along with tender for approval. 300mm square size samples labelled Glass, ACP sample shall be produced. All the approval samples of Material shall be stored by the success full bidder at site and to be produced as and when required for scrutiny.
- Provide accurate benchmarks for use in wall erection on all floors and if there are any errors or inconsistencies rectify at no extra cost.
- Tolerances for building frame and other work shall be strictly adhered to.
- Seal the joints within the wall and between adjacent constructions using the approved sealant.
- Remove and replace all damaged or disfigured components to the satisfaction of the Employer at no extra cost.
- Provide a separator at contact surface of dissimilar material whenever there is a possibility of corrosive or electrolytic action.
- Cleaning agents which are compatible with aluminum, glass, glazing, glazing material & Sealants shall only be used and the same shall get approved before use on work.
- Cleaning the glazing pocket before setting the glass.
- Cleaning the entire glazing, aluminum, composite panel and other components prior to handing cover.
- Quantities furnished in the bill of Quantities are indicative/tentative and are subject to
- Reconciliation on award of work between success full bidder and Employer / PMC / Architect, if there is any discrepancy at the shop drawing stage.
- Supply an adequate number of glass panels as spares so as replace broken panels in event of accident all breakage in the future for maintenance at mutually agrees rate. The number of spares required shall be decided by the PMC/Employer.
- Submittals should be provided as mentioned in the Technical Specification for approval.

- Tender submission should include a statement showing the conformity for each component with technical specificity on or otherwise never should specify / highlight the Material or components prospered, which does not comply with technical specification.
- Protect all components and material from damage or disfiguration of any kind of at all stages of work until handing over. The entire cladding work including all the components involved in these items shall be guaranteed by the external cladding agency as General and system Guarantee for a period 10 (Ten) years (After the DLP) including special guardant for glass, reflective coating of the Glass. Aluminum composite panel including coating and Sealant by the Manufacturer / Suppliers for the period specified in the technical specification in an approved Performa acceptable to the employer on a stamp paper. The guarantees from spec list applicators such as sealants, Double Glazed unit fabrication / Processor. Glass processing & coating, Aluminum such as for sealants, double Glazed unit fabrication / Processor, Glass procession & coating aluminum composite panel including skin Material from the Coil Manufacturer and processor etc., shall also be submitted form the respective Manufacturer / sub – vendor, counter signed by the spec list external cladding agency.
- The fabricator shall design the system suitable for installing the glass from the exterior surface after handing over and during maintenance by the Employer. However, the vertical in site the glazing in the system shall not be allowed during construction / erection of the system under any circumstances.
- All the drawings and samples submitted along with tender documents shall form part of the contract. Biddings are requested to submit the tender drawings and the samples of materials required along with tender submission duly signed & stamped, failing which the tender is liable for rejection.
- All the questionnaires attached to the tender document should be filled in by the bidder without fail and the same shall form part of the contract. Bidders are requested to fill in all the details called for in the pre-qualification, duly signed & stamped, failing which the tender is liable for rejection.
- Approvals for repeat comments beyond R02 submission will be charged as an additional fee to the client which will be further debited from contract fees. The penalty would be Rs. 5,000 per drawing sheet.
- All Aluminum structural profile thickness should be minimum 1.8mm and at mechanical engagement location thickness should be minimum 2.5mm.
- 1.2mm GI sheet to be used as water membrane wherever applicable.
- Aluminum weather bar to be provided wherever applicable (Top hung / Side hung or for water prone area of façade system)
- All drawings are to be read in conjunction with Tender BOQ & Technical specifications.
- Dead load brackets (horizontal slots) to have tack welded square washers.
- Slab mounted / Face mounted baseplate adjustment slots to have tack welded square washers.

- An anchor edge distance of minimum 75mm to be followed from the civil edge & for critical conditions where anchor edge distance requirement is more than 75mm should be followed as per anchor design calculations.
- All screw heads at the drainage location / drainage path, screw used for profile connections like transome connectors, outer frames etc. to be sealed with weather sealant.

Annexure No: 01					
FORMAT FOR DRGS & CALCULATION TO BE SUBMITTED BY FAÇADE BIDDER					
No	REQUIREMENTS	FORMAT			REMARKS
		HARD COPY		SOFT COPY	
		Size	No of Copy		
1	Tender Stage				
1.1	Tender Drawings	A3	01	-	Signed & Stamped
1.2	Tender BOQ	A4	01	-	Signed & Stamped
1.3	Tender Specification	A4	01	-	Signed & Stamped
1.4	General Contract condition	A4	01	-	Signed & Stamped
1.5	All Annexure Forms	A4	01	-	Signed & Stamped
1.6	Proposed System drawings for all Main elements by Bidders. Single details in Single Page only	A3	01	ACAD / PDF	Signed & Stamped
1.7	Structural Calculation for main Elements by Bidders	A4	01	Staad / PDF	Signed & Stamped
2	Post Award Stage				
2.1	System Drawing for All Wall Types (preferred in 1 : 1 scale) Single details in Single Page only	A2 / A3	05	ACAD / PDF	Signed & Stamped
2.2	Structural Calculation for All Wall types	A4	05	Staad / PDF	Signed & Stamped
2.3	Elevation / Section / Plan	A1	05	ACAD / PDF	Signed & Stamped
2.4	Shop Drawings (preferred in 1: 1 scale) Non-Typical / Interface / Junction details Single details in Single Page only	A3	05	ACAD /PDF	Signed & Stamped
2.5	As-built drawings	A3/A2	05	ACAD / PDF	Signed & Stamped

Note: During pre-bid stage façade contractor to provide interlock calculations for all typical windows with maximum panel size along with system proposal drawings & calculations.

Annexure No: 02A			
SPECIFICATION FOR LAMINATED GLASS			
NO	PARAMETERS	SPECIFICATION	STANDARD
1	Laminated Glass	As per calculations and tender drawings	ASTM C 1172
2	Outer Glass Type	As per calculations and tender drawings	
3	Inner Glass Type	As per calculations and tender drawings	
4	Size Tolerance	± 2 mm	
5	Type of Coating	-	ASTM C1376
6	Coating position	-	
7	Coating Edge Deletion	-	
8	Toughening (Outer Glass)	Heat Strengthened	
9	Surface Compression	3500-7000 Psi	ASTM C1048
10	Toughening (Inner Glass)	Heat Strengthened	
11	Surface Compression	3500-7000 Psi	ASTM C1048
12	Ceramic Frit Position	-	
13	Drill Holes (Both Lites)	As per manufacturer's guidelines	
14	Lamination Layer	1.52mm SGP (Clear) / 0.86mm SGP (Clear) / 1.52mm PVB / 0.76mm PVB as per tender specs	
15	Offset Tolerance for Lamination Layer	± 1 mm	
16	Roller Wave Distortion	Parallel to the bottom edge of the glass as installed (Parallel to the width of the glass)	
17	Strain Pattern	Should not be visible	
18	Toughening BOW	2mm (Maximum)	
19	Distortion / Roller Wave	Max 0.076mm / 300mm; Edge curl max 0.25mm	
20	Concavity / BOW in IGU	-	
21	Outer Glass Edge	Flat Machined ground mirror polished	

Annexure No: 02A			
SPECIFICATION FOR LAMINATED GLASS			
NO	PARAMETERS	SPECIFICATION	STANDARD
	Finish		
22	Inner Glass Edge Finish	Flat Machined ground mirror polished	
23	HS / FT Logo	FT logo in small Ø15mm within 25mm Edge of bottom corner	
24	Label	Type of Glass / Thickness / FT Mark / #	
25	Packing Method	Square foam pads between 2 glasses as separator to avoid scratches & damage to coating. Wooden crates with proper cushioning to avoid glass edge chip off & breakages. Seaworthy & local transport worthy	

Annexure No: 02B			
SPECIFICATION FOR SGU			
NO	PARAMETERS	SPECIFICATION	STANDARD
1	SGU	Thickness as per tender BOQ	ASTM E 774
2	Size Tolerance	± 2 mm	
3	Type of Coating	-	ASTM C1376
4	Coating position	-	
5	Coating Edge Deletion	-	
6	Processing	Heat Strengthened	
7	Surface Compression	3500-7000 Psi	ASTM C1048
8	Roller Wave Distortion	Parallel to the bottom edge of the glass as installed (Parallel to the width of the glass)	
9	Strain Pattern	Should not be visible	
10	Toughening BOW	2mm (Maximum)	
11	Distortion / Roller Wave	Max 0.076mm / 300mm; Edge curl max 0.25mm	
12	Concavity / BOW	2mm (Maximum)	
13	Edge Finish	Edge Arised	
14	Corner / Vent glass	Ceramic frit edges incase of stepped glass	
15	HS Logo	HS logo in Ø15mm within 25mm Edge of bottom corner	
16	Label	Type of Glass / Thickness / HS Mark / #	
17	Packing Method	Square foam pads between 2 glasses as separator to avoid scratches & damage to coating. Wooden crates with proper cushioning to avoid glass edge chip off & breakages. Seaworthy & local transport worthy	

Annexure No: 02C			
SPECIFICATION FOR LAMINATED GLASS			
NO	PARAMETERS	SPECIFICATION	STANDARD
1	IGU	As per structural calculations / Tender Drawings	ASTM E 774
2	Outer Glass Type	As per structural calculations / Tender Drawings	
3	Inner Glass Type	As per structural calculations / Tender Drawings	

4	Size Tolerance	± 2 mm	
5	Type of Coating	Magnetically sputtered vacuum deposition (MSVD)	ASTM C1376
6	Coating position	Face # 2.	
7	Coating Edge Deletion	Edge Deletion Required As per Supplier Guidelines	
8	Processing (Both Glass)	Heat Strengthened	
9	Surface Compression	3500-7000 Psi	ASTM C1048
10	Roller Wave Distortion	Parallel to the bottom edge of the glass as installed (Parallel to the width of the glass)	
11	Strain Pattern	Should not be visible	
12	Toughening BOW	2mm (Maximum)	
13	Distortion / Roller Wave	Max 0.076mm / 300mm; Edge curl max 0.25mm	
14	Concavity / BOW in IGU	2mm (Maximum)	
15	Outer Glass Edge Finish	Edge Arised	
16	Inner Glass Edge Finish	Edge Arised	
17	Aluminium Spacer	Thickness as per air gap (12,16, etc.) - Black Anodised	
18	IGU Offset Tolerance	± 1 mm	
19	Desiccant	Silica Molecular Sieve.	
20	Primary Seal	PIB seal (Polyisobutyle seal)	
21	Secondary Seal	Two-part IGU silicone sealant	
22	Sealant Type & Bite Size	Sika IG 25 / Dow Sil 982 Bite Size as per structural requirement	
23	Corner / Vent glass	Ceramic frit edges in case of stepped glass	
24	HS Logo	HS logo in small Ø15mm within 25mm Edge of bottom corner	
25	Label	Type of Glass / Thickness / HS Mark / #	
26	Packing Method	Square foam pads between 2 glasses as separator to avoid scratches & damage to coating. Wooden crates with proper cushioning to avoid glass edge chip off & breakages. Seaworthy & local	

		transport worthy	

Annexure No: 02D			
SPECIFICATION FOR SGU TOUGHENED / TEMPERED GLASS			
NO	PARAMETERS	SPECIFICATION	STANDARD
1	SGU	As per structural calculations / Tender Drawings	ASTM E 774
2	Size Tolerance	± 2 mm	
3	Type of Coating	-	ASTM C1376
4	Coating position	-	
5	Coating Edge Deletion	-	
6	Processing	Fully Tempered & Heat Soaking	
7	Surface Compression	9000-15000 Psi	ASTM C1048
8	Roller Wave Distortion	Parallel to the bottom edge of the glass as installed (Parallel to the width of the glass)	
9	Strain Pattern	Should not be visible	
10	Toughening BOW	2mm (Maximum)	
11	Distortion / Roller Wave	Max 0.076mm / 300mm; Edge curl max 0.25mm	
12	Concavity / BOW	2mm (Maximum)	
13	Edge Finish	Edge Arised	
14	Corner / Vent glass	Ceramic frit edges in case of stepped glass	
15	HS Logo	FT logo in Ø15mm within 25mm Edge of bottom corner	
16	Label	Type of Glass / Thickness / FT Mark / #	
17	Packing Method	Square foam pads between 2 glasses as separator to avoid scratches & damage to coating. Wooden crates with proper cushioning to avoid glass edge chip off & breakages. Seaworthy & local transport worthy	

Annexure No: 03		
DGU PERFORMANCE PARAMETERS		
NO	PARAMETERS	SPECIFICATION
1	Appearance	As per architect's approval on mock-up
2	Visible Light Transmission	45 – 70 %
3	Reflection In & Out	10% - 20%
4	SHGC	< 0.25
5	U Value	< 1.7 W/m²K

- Final approval would be based on mockup at site
- Minimum 3 glasses from each make shall be put up for Mockup as per approved makes list for client's / architect's approval. Any glasses selected during the mockup shall be considered for the project.

ANNEXURE 04 - LIST OF MOCK-UPS & TESTS

A. VISUAL MOCK-UP:

- Semi-Unitized Curtain Wall Glazing with Vertical Fin Feature
- Solid Aluminium Sheet Cladding
- System for Double Height Entrance Glazing

B. ONSITE TESTS BY NABL CERTIFIED LABORATORIES:

- Mechanical Anchor & OR Anchor Channel Pull-out test - By Manufacturer – 4 locations
- Onsite water test by NABL accredited laboratory as per tender BOQ

C. MECHANICAL & CHEMICAL TESTS REPORTS

Components	Test parameters	Number of tests	Intervals
Aluminium Extrusions	Alloy / Mechanical Properties	4 samples	Every Lot
Aluminium Finish	Dry Film Thickness	4 samples	Every Lot
Glass	Edge Finish / Sealant Bite / HS / FT / Distortion / Concavity / Convexity / Thickness	4 samples	Every Lot
EPDM Gasket	Shore A Hardness	4 samples	Every Lot
Anchor Fastener	Grade Check 316 / 304	10 samples	Every Lot
Fasteners	Grade Check 316 / 304	10 samples	Every Lot
MS Brackets	Galvanization DFT	10 samples	Every Lot
Sealant	As per manufacturer's guidelines		

PERFORMANCE MOCK-UP AT NABL ACCREDITED LABORATORY: ELEMENTS:

- Semi-Unitized Curtain Wall Glazing with vertical fins – 3 Bays & 2 storey height

PERFORMANCE CRITERIA FOR GLAZING

- Pre-Load for 50% of +ve design wind pressure
- Vent open close 5 times
- Air Infiltration test – 300 Pa (As per ASTM E 283)
- Static water test – 600 Pa (As per ASTM E 331)

- Dynamic water test – 600 Pa (As per AAMA 501.1)
- Wind load serviceability test 100%, +ve design wind pressure (As per ASTM E 330)
- Wind load serviceability test 100%, -ve design wind pressure (As per ASTM E 330)
- Seismic rack test - +/- 10mm movement (as per AAMA 501-4.09)
- Repeat static water test – 600 Pa (As per ASTM E 331)
- Proof load test 150% +ve design wind load (As per ASTM E 330)
- Proof load test 150% -ve design wind load (As per ASTM E 330)

TECHNICAL SPECIFICATIONS FOR ELECTRICAL WORKS

CONTENTS

A.	SCOPE OF WORK	3
B.	STANDARDS.....	5
C.	GENERAL.....	5
D.	DETAILED TECHNICAL SPECIFICATION	6
1.	HT PANELS	6
2.	DRY TYPE TRANSFORMER.....	18
3.	RAISING MAINS & BUSDUCTS	28
4.	LT PANELS	33
5.	APFCR PANELS	54
6.	CABLES.....	59
7.	CABLE CARRIER SYSTEM.....	66
8.	VARIABLE FREQUENCY DRIVES- VFD.....	70
9.	FANS / LIGHT FIXTURES & ACCESSORIES	77
10.	SWITCHES, SOCKETS & ACCESSORIES	86
11.	WIRING	91
12.	AUXILIARY POWER SUPPLY	96
13.	EARTHING & LIGHTNING PROTECTION	101
14.	UNINTERRUPTED POWER SUPPLY (UPS)	107
15.	INSTALLATION SPECIFICATION	115
16.	SOLAR SYSTEM WORKS	138
17.	DIESEL GENERATOR SETS.....	164
18.	LIFT SPECIFICATIONS	177
19.	ANNEXURE -1.....	185

A. SCOPE OF WORK

The scope shall include design, supply, testing at manufacturers works, packing, transportation, shipping, unloading at site, transportation to site, storage, insurance, transportation from stores to erection site, erection, site testing, commissioning, training, demonstration of performance guarantee tests of the power distribution system and handing over to Client including submission of hardcopy and soft copy of all as-built drawings, O&M manuals etc. required for successful operation of entire Tidel building.

The major items covered under the power distribution system are as follows:

- Ring Main Grid (RMG)-As per TANGEDCO requirements
- HT Panels
- Transformer,
- DG Set and Fuel Transfer system
- LT Electrical Panels
- Bus Duct & Rising main.
- HT&LT Power & Control cables & Terminations
- Cable Trays and cable containment system
- Distribution boards with MCB, RCBO etc
- Internal Point Wiring,
- Modular Switches and Sockets,
- Light fixtures, lighting Management System, Fans installation
- Earthing and Lightning Protection system.
- Roof Top Solar PV System
- UPS and Batteries
- EV Charging Sockets.
- External Road Light Fixtures
- Façade and Landscape light Fixtures
- Lifts works

Following are the scope of work involved in Electrical and its associated works.

- Incoming power supply from local Electricity Board to RMG & RMG configuration, EB metering arrangements shall be decided by local Statutory Department officials (TANGEDCO) directions.
- HT panels for consumer use at near RMG & near Transformers -Indoor/Outdoor Type based on application.
- 3 Nos. 2500 KVA, Dry type Distribution Transformer with OLTC
- 3 Nos. 2250 KVA, 415 V LT Prime Rated Diesel Generating Set with supporting 2nos of 20 KL Underground High-speed Diesel tank Backup and all its associated works for Room acoustics enclosures.
- LT Panels with Switchgears Above 400 A shall be of type tested assembly (As per IEC 61439) and LT Panels with Switchgears below 400 A shall be of Non type tested assembly (IEC 60349). All main breaker status (ON/OFF/TRIP) and metering shall be interfaced with BMS system.
- LT Sandwich busduct, bus trunking system & rising mains along with end feed unit & tapoff box.
- LDB's, PDB's complete with MCCB & MCB. All external Lighting DBs shall be with timers.
- Structural Earthing system shall be considered as per IEC 62305.

- Earth pits can be conventional or Chemical (Maintenance free) as per the applicational requirements.
- Conventional structural lightning protection system as per IEC62305 is used for all the building.
- All HT / LT power cable shall be XLPE insulated with FRLS properties. Control cables and wires shall be with PVC insulated ZHFR. Fire survival cables for Fire mode loads
- HT and LT power, Fire survival cables, control cables and Paired cables with required numbers of glands, lugs, termination kits, jointing kits, etc as required for interconnection between various electrical equipments along with cable markers
- Complete cable carrier system - cable trays, supports, brackets, clamps etc as well as GI conduits, floor and wall raceways, Hume pipes and all other installation materials as required for laying of power and control cables. HDPE/Hume pipes encased in concrete to be provided for crossing of cables below roads (If necessary).
- HDGI Ladder type and Perforated cable tray of approved colour shall be used as per requirements. Raceways & conduits shall be used wherever required. PVC wall race ways shall be used wherever specified.
- High Efficiency LED lighting shall be used for the lighting system. Occupancy sensors / Motion sensors / Lighting Control with the help of DALI shall be used wherever required. All embedded conduits shall be Heavy duty PVC type (HMS) and exposed conduits shall be MS type.
- Yard Lighting for substation, STP & indoor Lighting for Electrical Room & Pump rooms.
- Modular switches and sockets shall be used all sockets shall be universal type with shutters for safety.
- Modular UPS of the required capacity with redundant racks shall be provided for Emergency lighting & Emergency power loads.
- Roof top solar PV system along with all necessary accessories shall be provided.
- EV Charging Sockets as per LEED & Tamil Nadu EV Policy requirements.
- Passenger lifts with Machine room and DCS system
- Fire Cum Service lift, with Machine room.
- SITC of Complete relay setting, relay coordination, fault analysis, discrimination report and coordination documentation with calculation for the Power Distribution System
- Electrical system related miscellaneous items namely, three phase welding receptacles, rubber mats, danger boards, first aid charts, first aid boxes, insulated hand gloves, shock treatment chart, etc.
- All the required approvals from statutory department and related all the required coordination charges, professional charges, etc. shall be in the scope.
- Execution of electrical works shall be based on the final shop drawings prepared by contractor and approved by consultant. Its contractor responsibility to check the interferences with other services before issuing the final shop drawing for review of Consultant.
- Electrical system related miscellaneous items namely, three phase welding receptacles, rubber mats, danger boards, first aid charts, first aid boxes, insulated hand gloves, shock treatment chart, etc.
- Civil work for wall opening, minor core cutting in floors, minor chipping works for lighting inside building, cable burial including excavation, back filling, and compression etc as detailed in technical specification. Foundation frames, bolts, bolts of special design, embedment's, anchor fasteners and inserts.

- All equipment shall be suitable for smooth, efficient and trouble-free operation for power supply variations as mentioned herein below. The equipment shall be designed to give efficient and reliable performance even during various extreme atmosphere.
- All services necessary for the erection, testing and commissioning and all instruments/services required for carrying out performance testing of all items of the plant electrics covered under this specification shall be arranged by the BIDDER.
- Type test certificates for electrical equipments like panels, etc. not less than 5 years shall be submitted for consultants' approval. All equipment supplied shall be with valid Type test certificates. If valid type test certificates are not available, vendor has to perform all required type tests and furnish the certificates as per relevant standards. Supporting calculation/documents will not be treated as justification of non-availability of type test certificates.
- Routine test shall be conducted for all equipment (100%) like Transformer, DG, HT/LT panel, UPS, DB, cables, wires etc. during the final inspection.
- Providing and doing MS fabrication work as per the requirements.
- The final model for light fixtures, switches, sockets and industrial receptacles shall be selected based on the mockup approval by client/Consultant. Client/Consultant will select any one model out of the approved make indicated in the tender. Though other models are indicated in the tender, the model/make selected by client/consultant shall be supplied by the contractor without any price implication.
- Vendor to submit the QAP for all equipment. All test shall be conducted as per relevant standard and as per specification. Inspection will be carried out as per approved QAP.

B. STANDARDS

All Electrical works shall be carried out in accordance with following codes and standards.

1. PWD Specifications – As per Local PWD
2. Local By – laws
3. National Building Code of India – 2016.
4. Energy Conservation Building Codes.
5. Latest Relevant codes of National fire Codes.
6. Latest Relevant codes of Bureau of Indian Standards.
7. Institute of Electrical & Electronic Engineers (Design Hand Book).
8. Illuminating Engineering Society of North America (Design Hand Book).
9. NEC – NFPA 70, National Electric Code.
10. NFPA 101, Life safety code.
11. NEC, National Electric Code of India.
12. CEA, Central Electricity Authority regulations 2010.

C. GENERAL

Refer following Detailed Technical specifications for items which are not covered in above mentioned PWD Specifications. This specification is to be read along with SLDs and BOQs. In case of any conflict in specification, BOQ spec/ description will be followed.

D. DETAILED TECHNICAL SPECIFICATION**1. HT PANELS**

This specification covers the requirements of metal enclosed switchgear (VCB) rated for 3.3kV to 33 kV.

CODES AND STANDARDS

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed

MAIN PARAMETERS

The major parameters of the switchgear and other required features are given in data sheet. The BIDDER shall in his offer specifically conform compliance to these data in full. Deviation if any should be specifically brought out in the schedule of Technical Deviation.

FEATURES & DESIGN CRITERIA

The switchgear shall be indoor, metal clad with separate metal enclosed compartments for (a) control, metering and relaying devices (b) circuit breaker/ disconnecting switch (c) busbars (d) voltage transformers and (e) power cable terminations & current transformers. Doors with locking facility shall be provided for all compartments except for busbar compartment.

Adjacent switchgear cubicles shall be provided with inter-panel barrier sheets on both sides to ensure complete isolation. The bottom of the switchgear shall be fully covered by sheet steel.

Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material for single core cables.

All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphate and then painted with two coats of zinc rich primer paint. After application of the primer, two coats of finishing synthetic enamel paint oven baked / stoved, shall be applied. Powder coating method for above painting is preferable. For coastal areas, epoxy-based painting shall be provided.

The circuit breaker / disconnecting switch shall be fully draw out type and re-strike free. The circuit breaker / disconnecting switch shall have distinct service and test positions. In the test position the circuit breakers / disconnecting switch shall be capable of being tested for operation without energising the power circuits. Four normally open auxiliary contacts shall be provided for each of the service and test limit position switches.

The test position should preferably be obtained without the need to disconnect normal control connections and use of extension cords for testing.

The switchgear shall fully house the breaker both in the service position as well as in the test position.

The current transformers shall be mounted on the fixed portion of the switchgear and not on the breaker truck. The current transformer shall be placed in the cable chamber in such a way that its secondary terminals can be accessible without dismantling of current transformers & cable terminations.

The voltage transformers shall be draw out type & shall be mounted in such a way that it shall permit easy access, operation and maintenance.

The cable compartment shall house all power cable connections along with associated cable terminations. Wherever CBCT's are provided for earth fault protection, these shall also be located inside the cable compartment. Inspection window shall be provided to facilitate viewing cable terminations.

Each switchgear cubicle shall be fitted with a label in the front and rear of the cubicle. The rear side label shall be fixed on the non-removable part of the switchgear. Each switchgear cubical shall also be fitted with a rating plate clearly indicating the switchgear details such as designation, ratings, duty, etc. Each of the components such as relay, instrument, switch, fuse, and other devices shall be provided with separate labels.

Notes:

A stands for : Authorised

F stands for : Front

L stands for : Lateral

R stands for : Rear

Base channel frame of the switchgear with hardware shall be considered.

The switchgear shall be used to supply power to HV motors, transformers and other loads for various plants.

The switchgear shall be located in a clean but hot, humid and tropical atmosphere.

For continuous operation at specified ratings, temperature rise of the various switchgear components shall be limited to the permissible values stipulated in the relevant standards and/or this specification.

The Switchgear and components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the short circuit current without any damage or deterioration of material.

Circuit breaker shall not produce any harmful over-voltage during switching off induction motors, unloaded lines and unloaded transformers. If required, surge protective device shall be considered in the scope of supply to limit over-voltage.

Switchgear cubicle shall be so sized as to permit closing of the front access door when the breaker is pulled out to TEST position. The operating height of the switchgear shall be restricted within 750 mm to 1950 mm from floor level.

SAFETY INTERLOCKS AND FEATURES

Withdrawal or engagement of circuit breakers or disconnecting switch shall not be possible unless it is in the open position.

Operation of circuit breaker or disconnecting switch shall not be possible unless it is fully in service position, or in test position or in fully drawn-out position. The interlock shall prevent the closing of the circuit-breaker, switch or contactor in the service position unless any auxiliary circuits associated with the automatic opening of these devices are connected.

Operation of a disconnecting switch shall not be possible unless the associated circuit breaker is open.

Circuit breaker / disconnecting switch cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker / disconnecting switch carriage to cover the exposed live parts when the breaker is withdrawn.

Caution name plate with inscription "Caution - Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, e.g. incoming terminals of main circuit breaker/disconnecting switch.

A draw-out breaker / disconnection switch of given rating shall be prevented from engaging with a stationery element of higher rating.

The Circuit breaker / disconnecter carriage shall be earthed before the carriage reaches test position from fully withdrawn position. Further while racking out, earthing shall get disconnected only after test position. The earthing busbar & the contact shall be designed for full fault current with minimum contact resistance.

Emergency trip push button shall be provided for mechanical tripping of breaker with door closed condition and manual charging of closing spring to cater to emergency condition.

MAIN BUS BARS

Busbars shall be fully insulated with flame retardant heat shrinkable sleeves with removable shrouds for protecting all joints. The busbar phases shall be clearly identified with suitable colour coding at both end of each transport unit. The withstand temperature of sleeves shall be at least 5 deg centigrade more than maximum busbar temperature. The busbar temperatures shall be limited to the values indicated in the data sheet without forced cooling.

Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit.

DISCONNECTION SWITCHES

Unless otherwise specified, disconnect switches shall be 'off-load', draw-out type.

CIRCUIT BREAKERS

The circuit breaker type shall be VCB suitable for the switching duty as applicable to the type of loads being fed from the switchgear & over voltages shall be within limits for the type of loads connected.

Adequate provision shall be made on circuit breakers for motor switching off to limit the over voltage to 2.2 p.u. rated peak line to earth voltage (1.0 microsecond. to crest). Suitable surge arrestors, if necessary shall be provided to restrict the voltage peaks during switching off motor, to 2.2 p.u. of rated peak line to earth voltage.

Mechanical trip and close functions with pad locking facility shall be provided for circuit breaker operations during auxiliary supply failures conditions.

All VCB trucks of same rating shall be interchangeable. Closing coil shall be operable with control supply voltage variation in the range of 85-110% and tripping coil shall be operable in the range of 70-110%.

AUXILIARY CONTACTS

Auxiliary switch mounted on the fixed portion of the breaker and directly operated from the breaker operating mechanism shall be provided and shall have minimum 6 'NO' and 6 'NC' potential free contacts. The contacts shall be rated for 10 amps, 230V/240V A.C. and 1 Amp.

(inductive breaking) at 220V D.C. The contacts shall be in addition to those utilised in the breaker control circuit. The above auxiliary switches shall not operate when the breaker is withdrawn to test position and operated. Latched type auxiliary relay shall be used for further multiplication of breaker auxiliary contacts and shall be used as per scheme requirement. Non-latched type auxiliary relay shall be avoided.

SPRING OPERATED MECHANISM

The operating mechanism shall be complete with motor, opening and closing springs, limit switches for automatic charging and all necessary accessories. Facility for manual charging of the closing spring shall be provided. The operating mechanism shall be trip-free and non-pumping electrically. An anti-pumping relay to achieve electrical anti-pumping feature shall be provided even if the breaker has provision for anti-pumping by mechanical arrangement. At least one O-CO operation shall be possible upon failure of auxiliary power supply.

EARTHING

An earthing bus shall be provided at the bottom and extended throughout the length of the switchgear. It shall be bolted / welded to the frame work of each unit and each breaker/disconnector earthing bus. The earth bus shall be suitable to receive the purchaser's earthing conductor size specified in the data sheet

Busbar and circuit earthing facility shall be provided either through earthing switches or separate earthing trucks. These earthing devices shall be suitably interlocked with the circuit breaker / disconnector to avoid accidental earthing of live parts.

All non-current carrying metal work of the switchgear shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

Positive earthing of the circuit breaker/disconnector frame shall be maintained both in service and test position.

SWITCHGEAR ACCESSORIES AND WIRING

Switchgear shall be supplied completely wired internally up to equipment and terminal blocks and ready for the PURCHASER's external cable connections at the terminal blocks. Inter panel wiring between cubicles of same switchgear shall be provided by the VENDOR.

All auxiliary wiring shall be carried out with 1100 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall not be less than 2.5 mm² for CT circuits and 1.5 mm² for other circuits. Red, Yellow & Blue coloured wires shall be provided up to the last equipment for CT & VT secondary circuit. Black coloured wire shall be provided for neutral. All control wires crossing the hinged door shall be provided with mechanical protection in the form of flexible PVC hose. FRLS cable shall be used for panel wiring.

Ring type tinned copper crimping lugs shall be provided for termination of all wires & insulating sleeves shall be provided on the crimp to prevent exposed live wires.

Tubular printed "Cross dependent end marking" ferrules shall be provided at each termination end. Wires used in circuit breaker tripping circuit shall have red coloured ferrules engraved with letter 'T' at end.

Terminal blocks shall be of stud type, 1100 volt grade, 10 amps. rated complete with insulated barriers. Terminal blocks for CTs and VTs shall be provided with test links and isolating facilities. All terminal blocks shall be shrouded by transparent epoxy sheet.

All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks. Minimum 20% spare terminals shall be provided.

Accuracy class for indicating instruments shall be 1.0 or better. All analog instruments shall

be minimum 96 mm square, 2400 scale and taut band for flush mounting with only flanges projecting. Energy meters shall be of accuracy class 1.0 or better. All digital instruments shall also be minimum 96 mm square.

Multifunction meters for measuring current, Voltage, frequency, power factor, MW, MVAR, MWh, MVA, MVAH and MVARh with built-in test and communication facilities shall be provided if specified in data sheet enclosed.

Main protection relays shall be numerical type fully meeting the protection functions specified. Relays shall be suitable for flush mounting with only flanges projecting. Meters and relays shall be communicable type with IEC 61850 compliant.

All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose and shall be included in the VENDOR's scope of supply. Preferably all auxiliary relays and timers shall be supplied in draw-out cases. Externally operated hand reset fault indicators shall be provided on all relays if not specified separately. Timers shall be of electromagnetic or electronic type only.

Control and instrument switches shall be rotary type provided with escutcheon plates clearly marked to show operating position and suitable for semi flush mounting with only switch front plate and operating handle projecting out. Switches shall be non-lockable type if not specified separately.

Breaker control switches shall be pistol grip black and selector switches shall be oval or knob and black. Breaker control switches shall be 3 position spring return to neutral type. Instrument selector switches shall be of the maintained stay-put type. Contacts of the switches shall be spring assisted and contact faces shall be with rivets of pure silver. The contact ratings shall be adequate to meet the requirements of circuit capacity in which they are used.

Push buttons shall be provided wherever specified. They shall be provided with inscription plates engraved with their functions.

Indicating lamps shall be Cluster LED type. The minimum indications shall include circuit breaker ON / OFF/ TRIP, test & service position, spring charged / discharged, trip circuit healthy & auxiliary supply healthy.

Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 230V/240V, 1 ph, 50 Hz supply. They shall be complete with MCB's and thermostat.

Each switchgear panel shall be provided with 230/240 Volts, 1 phase, 50 Hz, 6 amps. 3 pin receptacle with switch located in a convenient position. LV compartment (control & metering) shall be provided with illumination lamp (LED) with door switch.

Provision shall be made for receiving, distribution and isolating of auxiliary D.C. and A.C. supplies for controls, space heating, etc. MCB's shall be provided for isolation of auxiliary power supplies. The MCB ratings shall be so chosen as to ensure selective clearance of sub-circuit faults.

The D.C. and A.C. auxiliary supply shall be distributed inside the switchgear with necessary isolating arrangements at the point of entry and with sub-circuit MCBs as required. 2x100% DC auxiliary power supplies shall be provided for the switchgear with manual changeover facility. DC failure annunciation shall be on AC auxiliary supply.

INSTRUMENT TRANSFORMERS

The ratings of instrument transformers specified in Data Sheet are estimated ratings. For Protection CT's, the minimum CT burden shall be 10VA with accuracy class of 5P20. For

metering CT's, the accuracy class shall be 1.0 & ISF ≤ 5 . Further for metering CT's, the actual connected burden shall be between 25 to 100%. CT VA burden & the accuracy class shall be valid for this range. BIDDER shall ensure that the specified ratings are adequate for the relays and meters furnished by him. If specified ratings are not adequate the BIDDER shall offer instrument transformers of required rating.

The CTs shall withstand momentary and short time current ratings of the associated switchgear. CTs & VTs shall be of the cast resin type and completely encapsulated. All CTs shall be window type.

The CTs shall be provided with quick disconnecting type of shorting links at CT secondary terminals.

The core balance CTs shall be suitable for the respective outgoing feeders and shall be suitably supported.

VTs shall be single phase, drawout type. VTs shall be provided with fuses on primary and MCB's on secondary side, except those terminals which are required to be connected to earth. These shall have an isolating link. Fuses on primary side shall have rupturing capacity equal to the switchgear rating. Suitable shutters shall be provided to seal off the HV live terminals when VT's are withdrawn.

One additional open delta winding with damper resistance shall be provided for all VTs.

VACUUM CONTACTOR UNITS

The vacuum contactor unit shall be suitable for the switching duty (AC-3 or AC-4 operation) as applicable to the type of loads being fed from the switchgear & over voltages shall be within limits for the type of loads connected.

The vacuum contactor unit shall be with HV HRC fuse and 3 pole contactors with electromechanically operated mechanism.

It shall have limited short circuit making & breaking capacity and suitable for high switching frequencies (more than 10,000 operating cycles).

It shall have with two different modules.

High voltage section: Vacuum interrupters and main contactor terminals.

Low voltage section: Operating mechanism, electronic module, mechanical closing latching and auxiliary contact block.

It shall be suitable in order to prevent impermissible over voltages when performing switching operations in inductive circuits, the chopping current must be limited to the lowest possible value.

It shall also have separate shunt trip coil.

If the vacuum contactor unit is used for motor feeder, BIDDER shall consider type-2 coordination and provide necessary coordination chart.

CABLE TERMINATION

Necessary number and sizes of double compression cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc.

Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper/aluminium depending on cable conductor and of solder less crimping type.

All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc. shall be supplied.

SPARE PARTS

The BIDDER shall furnish a list of recommended spare parts for five years operation along with unit prices.

TESTS AND REPORTS

Type test reports for the switchgear and circuit breakers shall be furnished along with the tender. Type tests shall be carried out free of cost to prove the design if not tested in the previous five years.

The switchgear, circuit breakers and all associated equipment shall be tested in accordance with relevant standards. All routine tests shall be carried out.

Type test and routine test reports shall be submitted for the PURCHASER's approval before the equipment is despatched. Bound copies of test reports shall be furnished along with the switchgear.

All meters and other reference devices used for testing shall have valid calibration from reputed national laboratories/institutes. Inspection by PURCHASER/ENGINEER will not be carried out unless the VENDOR furnishes calibration certificates at the time of inspection.

Equipment shall not be despatched unless the test certificates are duly approved by the PURCHASER/ENGINEER.

The manufacturer shall submit following Type test reports to prove the capability and suitability of his offered switchgear. The switchgear should have been subjected to all type tests at an internationally recognized testing station, like PEHLA, KEMA or NABL accredited laboratory or an independent test laboratory.

Type tests certificates / reports shall be considered acceptable if they are following the latest applicable relevant IEC Standards

The following tests shall be carried out as a minimum requirement:

Short Time Current Test

Short Circuit Test duties on Circuit Breaker.

Impulse withstands Test.

Power Frequency withstand Test

Temperature Rise Test.

Internal Arc Test – AFLR – 26.3kA for 1 Sec.

Mechanical Endurance test on Circuit Breaker.

Test to prove Degree of Protection of enclosure.

Capacitor Switching Test.

ROUTINE TESTS :

Routine tests shall be carried out in accordance with IEC 62271-200 standards.

These tests shall ensure the reliability of cubicle.

Below listed test shall be performed as final acceptance tests at manufacturer's works before the delivery of switchgear :

Withstand voltage at power frequency

Bidder's Stamp & Initials

Withstand voltage on the auxiliary circuits

Operation of functional locks, interlocks, signalling devices and auxiliary devices

Suitability and correct operation of protections, control instruments and electrical connections of the circuit breaker operating mechanism

Measurement of the resistance of the main circuit

Verification of wiring

Visual inspection

DRAWINGS AND DATA

The following shall be furnished as part of the tender:

General arrangement drawing showing plan, elevation, typical section views, weight & panel line up GA.

Foundation plan showing location of fixing channels, floor openings, flooring requirement etc.

Schematic wiring drawings and Bill of materials for each module.

Technical literature on the breakers offered.

RING MAIN GEAR

SPECIFIC REQUIREMENTS:

The scope of this specification covers the complete design, manufacture, testing at manufacturer's works, inspection at manufacturer's works, supply, packing, forwarding and delivery from place of storage/ manufacturer's works to erection site including transit insurance, supervision of erection, testing & commissioning, performance demonstration at site of one (1) outdoor metal enclosed RMG

Supply of base frames / Steel structural supports for embedment in ground required for 33kV RMG is included in Bidder's scope.

PURCHASER reserves the right to add/delete different types of switchgear cubicles, breakers accessories, if found necessary during detailed engineering. Unit prices quoted by Bidder shall be binding on him for addition/deletion.

One set of spares recommended for three years of trouble-free operation, such as closing & tripping coil sets, gaskets, spring charging motor, bus bar support insulators etc. & critical spares. List of all recommended spares along with unit rates shall be furnished by Bidder along with commercial offer.

RMG shall comply to all requirement indicated in the TANGEDCO regulations in addition to the below specifications.

CODES AND STANDARDS:

The equipment shall fully comply with the requirements of enclosed specifications and the latest editions of codes and standards as specified in data sheet.

Other National Standards will be acceptable only if they are established to be equal to or superior to standard listed above and in data sheet. In all such cases copies of English translation of all standards shall be enclosed with the BID.

In the event of any conflict between the codes and standards referred to in the specification and more stringent shall govern.

CONSTRUCTION

The Outdoor enclosure shall be made up of CRCA of 3 mm thickness or galvanized of minimum 1.6 mm thickness, high tensile steel which must be tropicalised to local weather conditions, grit/sand blasted, thermally sprayed with Zinc alloy, phosphate or should follow the 7 tank pre-treatment process and be subsequently Painted with polyurethane based powder paint. The overall paint layer thickness shall be not less than 80 microns. Bidder shall produce QA plan and controlled document when demanded by Purchaser.

The metal base shall ensure rigidity for easy transportation and installation.

The enclosure should have two access doors one for the operation and relay monitoring and other for the cable access. The doors shall be provided with proper interlocking arrangement for safety of operator.

All doors shall be provided with locking facility or it shall not be possible to open or remove them before doors used for normal operation have been opened. When they are closed, they shall provide the degree of protection specified for the enclosure.

The doors shall open outward at an angle of at least 90 Deg & be equipped with a device able to maintain them in an open position.

Ventilation openings if provided, shall be so arranged or shielded that same degree of protection as specified for enclosure is obtained.

All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequately sized terminal intended for connection to the earth system of the installation, by way of flexible jumpers/strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry.

There shall be an arrangement for internal lighting activated by associated switch.

Labels for warning shall be specified in min three languages including English, Hindi and Local Language. All the labels and manufacturer's operating instructions etc. shall be durable & clearly legible. They should be located within operating height of the equipment.

The paints shall be carefully selected to withstand tropical heat and rain. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

SWITCHGEAR

The circuit breaker type shall be VCB Vacuum Circuit Breakers - Please Refer above HT panel section for VCB and its accessories, wirings, Vacuum contactors specifications and same specifications only shall be followed.

LOAD BREAK SWITCH BREAKER WITH INTEGRAL EARTH SWITCH (IF REQUIRED)

The Unit shall consist of Manual operated/ Motorized spring assisted, three pole Load Break Switch, with integral fault making / breaking earth switch.

It shall be ensured both the LBS and earth switch shall be naturally interlocked to prevent them being switched 'ON' at the same time & to make the LBS trip when the Earth switch is ON.

The selection of the main/earth switch lever on the panel, which is allowed to move only if the main or earth switches in the off position. Provision for padlocking shall be available for either the main or earth position.

The Load Break Switch shall be maintenance free type.

The position of the power and earthing contacts shall be clearly visible on the front of the switchboard. The Load Break Switch shall have at least 2 positions: Open-disconnected & closed and shall be constructed in such a way that natural interlocks prevent all unauthorized operations. They shall be fully mounted and inspected in the factory.

An operating mechanism can be used to manually close the circuit breaker and charge the mechanism in a single movement. It shall be fitted with a local system for manual tripping by an integrated push button. There will be no automatic re-closing.

The Load Break Switch shall have complete interlocking arrangement at fully inserted and fully drawn out position of the breaker. Withdrawal of circuit breaker shall not be possible unless it is in open position and operation of circuit breaker shall not be possible unless it is fully in service position or is fully drawn out.

Comprehensive interlocking system to prevent any dangerous or inadvertent operation shall be provided.

Provision for intertripping and closing interlock shall be provided between upstream (HT) and downstream (HT) breakers such that, If upstream (HT) breaker trips, downstream (HT) breaker shall also trip and downstream (HT) breaker cannot be closed unless upstream (HT) breaker is closed.

Automatic safety shutters shall cover live parts when the breaker is withdrawn and all other standard safety features shall be provided.

All operating switches shall be accessible without opening the compartment door.

Breaker control switches shall be of pistol grip type and selector switches shall be oval or knob. Breaker control switches shall be 3 position spring returns to neutral.

CURRENT TRANSFORMERS:

Current Transformers are Epoxy Resin cast, dual core dual ratio type and shall comply as per IS 2705. The rating & Class of CT (both metering and protection) should be decided by TANGEDCO directions

POTENTIAL TRANSFORMERS:

Potential Transformers are Epoxy Resin cast Draw-out type and shall comply as per IS 3516.

The rating & Class of PT should be decided by TANGEDCO directions

PROTECTION RELAYS:

All relays as indicated in '33kV Single Line Diagram' shall be mounted on the RMG.

Main Protection Relays shall be Numerical type with IEC 61850 protocol. Test terminal plug block for testing shall be provided.

Relays are of Flush Mounted Draw-out type pattern fully Comply as per IS 3231. All other Instruments/Switches and Wires & Cables shall comply with the latest IS.

BUSBARS

Electrolytic Grade Copper Busbar shall be used as Main Busbar and interconnections. Busbar shall have uniform cross section throughout the Ring Main Switchgear. Busbar is provided with a heat shrinkable PVC sleeve. Colour coding as per IS shall be made at regular intervals.

CT parameters indicated are tentative and subject to finalisation after award of contract. Bidder shall agree to accommodate changes, if any, without any extra price to PURCHASER.

GENERAL REQUIREMENTS

The continuous current ratings of the droppers in each switchgear cubicle shall at least be equal to the corresponding breaker rating. However short time current rating shall be same as the short time current rating of the bus-bars.

All bolted joints in the body of switchgear shall be earthed through flexible jumpers.

Circuit breakers of same ratings shall be completely inter-changeable with one another.

Panel wiring shall be securely supported, neatly installed by lacing and tying, readily accessible and connected to equipment terminals and terminal blocks.

Selector switches shall be of maintained (stay put) type. Ammeter selector switches (if provided) shall have facility such that the ammeters can be repeated at local and remote.

230V AC, 24V DC and other voltages shall be segregated to avoid mix-up of voltages.

The sizes of the cable indicated in '33kV Single Line Diagrams' are tentative. The actual size of the cable will be informed to successful Bidder during detailed engineering.

Split gland plate to be provided.

D.C changeover scheme for control supply to be provided.

All bus bar inside panel shall be fully insulated to withstand normal rated as well as surge voltages and insulating boots shall be used at bus tap off & cable connections.

It shall be entirely the responsibility of the Bidder to ensure that characteristics of CTs, PTs and all other devices offered by him are such as to be suitable for the purpose for which they are intended.

Vendor to share the CIVIL Foundation Drawings.

MAINTENANCE REQUIREMENTS

Vendor shall supply maintenance tools including special tools, if required, for attending to the equipment supplied at no extra cost. As far as practicable, the equipment and accessories shall be so designed that no special tools are necessary for installation and maintenance of the equipment. However, if special tools are required, the Bidder shall supply one complete set for each type of equipment.

Bidder shall include supply of start-up and essential spares.

Vendor shall furnish detailed inter-panel diagrams, terminal connection wiring diagram and detailed component layout drawings to enable PURCHASER to carry out maintenance work.

Bidder's Stamp & Initials

Vendor shall ensure the use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to national standard.

COMMISSIONING SERVICES:

The VENDOR shall indicate the man day rates for specialist commissioning engineers and shall arrange for such visits if desired by the Purchaser. The Bidder shall note that the payment will be made on the basis of actual duration of time of personnel for which their service is required at the rates indicated. The man day rates for supervision charges shall be lump sum per day including travelling cost of Vendor's engineer from his office to site, lodging, boarding charges, local travel and incidental expenses, insurance charges etc.

Prices quoted shall include the cost of all routine tests specified in the Datasheet and the specifications. As regards type tests, copies of the earlier test certificates carried out on equipment of similar ratings shall be furnished along with the offer.

The bidder shall schedule his design, manufacture, testing at manufacturer's works, supply, packing, forwarding and delivery from place of storage/ manufacturer's works to erection site including transit insurance as per the schedule mutually agreed by Bidder & GCSC

Detailed General Arrangement and bill of material including detailed catalogue/specifications/datasheets of the equipment & components.

Note:

The RMG panel shall be manufactured as required by the TANGEDCO authorities directions and approval shall be obtained including commissioning.

Any additional features required by the authorities shall be carried out at no extra cost.

2. DRY TYPE TRANSFORMER

3.1 SCOPE

This specification covers the requirements of cast resin dry type distribution transformers up to 36kV, 3150 KVA with all the accessories and fittings for efficient and trouble free operation.

3.2 CODES AND STANDARDS

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations, and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

3.3 GENERAL CONSTRUCTIONAL FEATURES

All material used shall be of best quality and of the class, most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions, overloads, over-excitation, short-circuits as per specified standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

The transformer shall be compact and suitable for easy installation at site. It shall be of modular design; i.e. windings can be individually mounted and replaced on site. The transformer shall be provided with 4 Nos. Bi-directional cast iron rollers fitted on cross channels to facilitate the movement of the transformer in both directions.

These rollers shall be suitable for being turned through an angle of 90deg. and locked in that position when the transformer/enclosure is jacked up. Steel bolts and nuts shall be galvanized. Transformer shall be suitable for tropical climate and shall be anti-fungal treated. It shall be capable of withstanding thermal effect and stresses caused by short circuit or voltage surges. Rating and diagram plates of stainless steel shall be provided on LT box of the transformer and shall be easily accessible. Rating and diagram plate shall be riveted to the transformer enclosure at a proper height so that it is readable. The rating diagram plate shall bear details as specified in relevant standards. Lifting eyes or lugs shall be provided on all parts of the transformer, which require independent handling, during loading, unloading, assembly or dismantling.

3.4 CORE

The magnetic circuit shall be constructed from high grade cold-rolled non-ageing grain-oriented silicon steel laminations with non-hygroscopic insulation material on both sides. The magnetic circuit shall be of "core type" Construction. The core shall be built up with 'step-lap' configuration. The grade of laminations shall be low loss type to meet the loss figures specified in the Relevant standard

It shall be carefully interlaced step lap epoxy arranged yoke. It shall be mitered to have low noise and losses. An adequate painting of resin coat shall cover the complete core and the

clamping structure and shall protect it against corrosion. The Final assembled core shall be free from distortion. It shall be rigidly clamped to ensure adequate mechanical strength and prevent vibration during operations.

The core shall be provided with lugs suitable for lifting the complete core & coil assembly. The core clamping structure shall be designed to minimise eddy current loss and bolts shall not pass through the laminations for any purpose. The bandages for the core shall be of polyester tape/fibre glass, the spacers for clamping the windings shall be of high-quality rubber/fibre glass to withstand the temperature rise specified in Relevant standard and the supports shall be of porcelain.

The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand a voltage of 2500V for one minute.

3.5 WINDINGS

LV WINDING

LV Winding shall be of copper foil, coated with class F insulation, epoxy resin reinforced with fibre glass layers pre-impregnated and casted under vacuum, to be thermally bound to the winding. The conductors shall be transposed at suitable intervals in order to minimize eddy current and to equalize the distribution of current and temperature along with windings.

Insulation of LV winding shall be adequate to withstand surge voltages appearing across them as a result of transfer due to an impulse striking on HV terminals. Adequate cooling ducts in epoxy cast shall be provided in the LV winding to obtain the required cooling in axial and radial directions.

The resin used for winding insulation shall be non-hygroscopic. It should be possible to energise the transformer without drying even after long period of service interruption. In case of Dyn11 transformers, neutral shall be brought out in open for solid earthing on secondary side.

The winding shall be designed to reduce the out of balance forces in the transformer at all voltage ratios at all operating conditions. The winding shall be so designed that all coil assembly of identical voltage rating shall be interchangeable and field repairs to the windings can be made without special equipment's.

HV WINDING

HV Winding shall be of copper wire, double layer winding, and cast under vacuum with epoxy resin. The resin shall be pure low viscosity epoxy resin, fibre glass reinforced. The resin cast winding shall be void free.

Insulation of HV winding shall be Class 'F' with temperature rise limited to Class 'B'. Resin on winding shall be casted under vacuum and then pressure impregnated. It shall be thermally bound to the winding after initial curing. Casting shall be cured thermally in controlled autoclave with complete cycle and temperature (typically 145°C for 4-6 hrs.) recommended by manufacturer / standards.

The winding shall be designed to reduce to a minimum the out of balance forces in the transformer at all voltage ratios at all operating conditions. The winding shall be so designed that all coil assembly of identical voltage rating shall be interchangeable and field repairs to the windings can be made without special equipment. Adequate cooling ducts in epoxy cast shall be provided in the HV winding to obtain the required cooling in radial and axial directions.

HV and LV winding shall be suitably braced and supported at top as well as bottom to withstand short circuit stresses set up by surges and damage because of inertia.

The resin casting process shall be carried out under the most strict and automated controlled conditions in order to ensure optimum insulating and mechanical properties.
The coil finishing shall provide smooth surface eliminating dust accumulation and give effective cooling.

3.6 ENCLOSURE

The enclosure shall be of CRCA mild steel sheet. The enclosure frame shall be fabricated using suitable CRCA pressed and shaped sheet steel of thickness not less than 3mm for structural members and 2mm for all doors & covers. Enclosure shall be provided with adequate doors, covers for inspection, maintenance and removal of the active parts from the enclosure.

The material used for gaskets shall be cork neoprene or nitrile butyl rubber gasket. Suitable mechanical stops shall be provided to prevent excess squeezing of gaskets.

The enclosure shall not have degree of ingress protection less than IP-33. Enclosure doors/covers shall be pad lockable and shall have limit switch for tripping HV circuit breaker to avoid accidental contact with live parts. Instruction in three languages (Hindi/English/Local language) shall be displayed on each openable door/cover.

The transformer shall be natural air cooled, or fan cooled as indicated in relevant standard . If forced cooling is specified, cooler fan shall be isolated from live parts and shall have separate door without interlock.

An emergency trip push button of lockable type shall be provided at a prominent and convenient place near the transformer to facilitate easy tripping of HV circuit breaker feeding the transformer during an emergency. The enclosure door shall be interlocked with service transformer incoming breaker such that the door can be opened only when the service transformer HV side circuit breaker is in Test/Isolated position and HV side circuit breaker can be closed only when the doors are closed.

All wheels should be detachable and be made of cast iron. Wheels shall be mounted on separate ISMC (MS channel), provided at bottom of the frame.

Lifting eyes or lugs shall be provided on all parts of the transformer, which require independent handling, during loading, unloading, assembly or dismantling such as core , enclosure etc.

3.7 EARTHING

The framework and clamping arrangement of core and coil shall be suitably earthed internally to the body of enclosure. Separate 2 nos. earthing terminals shall be provided on enclosure for connection to PURCHASER's earth grid. Core shall be earthed to the frame. Suitable arrangement shall be provided for disconnecting the core earthing for insulation measurement.

2Nos. separate earthing pad / terminals shall be provided on the HV cable box for armour earthing from inside and for OWNER's grid connection from outside. Apart from the neutral leads for power connection, a separate neutral terminal shall be provided to facilitate termination of 2 nos. earthing conductors, which in turn will be connected to two (2) distinct earthing pits by direct connection. The connection may be by insulated cable or by bare strip. In case of cable connection, suitable cable box to terminate the cables shall be provided. Flexible earthing braid shall be provided between all metal parts joined with gaskets.

Arrangement for supporting 2 runs of GI, up to grade level, from neutral terminal connection installed outside shall be provided.

3.8 TERMINATION

Transformers shall be suitable for the following terminal arrangements:

- LV Side: - The LV side including the neutral shall be brought out through bushings and suitable arrangement for bus trunking with horizontal or vertical take-off of bus duct or cable box suitable for top/ bottom cable entry as specified in Relevant standard shall be provided.
- HV cable box: - HV side leads shall be brought out through bushings to a cable box and cable box shall be suitable for top or bottom entry as specified in Relevant standard and provided with plug-in terminals.
- Support insulator i.e. bushings material shall be of porcelain/ epoxy resin cast.

Manufacturer shall indicate the method of connection (type of welding /brazing etc.) between the winding and the termination bar.

3.9 MARSHALLING BOX

A marshalling box shall be provided for housing transformer control and other signalling equipment. The marshalling box shall be of mild steel sheet and shall be with IP 54 or better degree of protection for enclosure. The marshalling box shall be complete with necessary cable glands and cable lugs. All sensor and equipment connection shall be wired up to the terminal with ferrules.

The marshalling box shall accommodate digital temperature indicator and gland plates for incoming and outgoing cables. Marshalling box shall be provided with toughened glass visor to facilitate the reading of temperature indicators. Marshalling box shall be provided with cubicle illuminating lamp along with control switch and door limit switch and a thermostatically controlled space heater. Also it shall have one 16A utility socket.

All spare contact and terminals shall be wired up to the terminal block. 20% spare terminals shall be provided. Terminal block shall be rated for 10A. Wiring shall be with PTFE/FRLS PVC insulated multi stranded copper conductors of sizes not less than 1.5 sq.mm for control cables and 2.5 sq.mm for CT circuits. CT terminals shall be provided with shorting and earthing facility. Printed identification ferrules shall be of yellow colour with black lettering.

Control voltage shall be 220V/110V/24V DC for all equipment, as per project requirements and 230V, 1 phase, 50 Hz for utility requirements.

3.10 PAINTING

All interiors and exteriors of transformer/enclosure / shall be finished and painted to produce a neat, fire resistant and durable surface which would prevent rusting and corrosion. Sheet metal components shall be pre-treated using the seven-tank phosphating process consisting of de-greasing, acid pickling, de-rusting, phosphating and passivation including repeated rinsing in between, thickness of painting shall be minimum 75-80 microns. The colour shade of the sheet metal work shall be as indicated in Relevant standard.

3.11 ELECTRICAL AND PERFORMANCE REQUIREMENTS

Transformers shall operate without injurious heating at the rated KVA at any voltage within + /- 10 percent of the rated voltage of that particular tap.

11.2 Transformer shall be capable of delivering rated current at a voltage equal to 105% of rated voltage. Transformers shall be designed for 110% continuous overfluxing withstand capability.

Overloads shall be allowed within the conditions defined in the loading guide of the applicable standard. Under these conditions, no limitations by terminals, tap changers or other auxiliary equipment shall apply. Transformer shall be self-extinguishing in the event of fire or arcing and no toxic or corrosive gases shall be released.

There shall not be any risk of cracking of the epoxy casting in the transformer.

Transformer shall have partial discharge level of less than 10pC.

The neutral terminal of windings with star connection shall be designed for the current that can flow through this winding. Transformer shall be of low noise.

Bidder's Stamp & Initials

Transformer shall be certified for following:

- (a) Class for "Fire Behaviour"- As specified in Relevant standard or Section C
- (b) Class for "Climatic"- As specified in Relevant standard or Section C
- (c) Class for: - "Condensation and humidity"- As specified in Relevant standard or Section C

Transformer shall be suitable for switching with Vacuum Circuit Breakers (VCBs). Resonance frequency of the winding shall be such as to avoid resonance with the switching impulse of VCBs and overstress of the insulation.

The sound level of the transformer shall not exceed the limit indicated by relevant standard under any specified operating conditions.

3.12 FITTINGS AND ACCESSORIES

The transformer shall be provided with following fittings and accessories:

- Enclosure with Top cover
- Rating & diagram plate
- Terminal markings plate.
- 2 Earthing terminals.
- Cable box with HV plug-in connectors.
- Bus duct termination arrangement/ cable box
- Neutral cable box for neutral earthing if applicable
- Lifting lugs
- Hauling lugs
- Base Channel
- Undercarriage with 4 nos. rollers, which can be turned 90 degrees and bidirectional.
- High-voltage danger notices against touching of coils.
- Louvers
- Winding Temperature indicator with RTD sensor (minimum 2 per phase). Pre-set PTC sensors shall be provided and attached to each of the LV winding as close as possible to the hottest spot. The PTC sensors shall be selected in order to protect both, HV and LV windings. Contacts for alarm and trip and shall be suitable for 220V/110V/24V D.C. The indicators shall have a suitable RS 485 port for transfer of data to plant SCADA/DCS system).
- Marshalling Box.
- ON LOAD Tap Changing Links (Refer detailed specification for OLTC)
- The tap-changing shall be performed by link mechanism. The links shall be accessible after opening the door/cover.
- Cast resin current transformer on transformer neutral for stand-by earth fault protection, Restricted Earth fault protection, as specified in relevant standard.
- All necessary cable glands, cable lugs, armour earthing clamps, terminal connectors, cable sealing ends and accessories required for termination of the PURCHASER's cables/ bus duct shall be included.

3.13 TESTS

The routine tests shall be carried out as per applicable standards and shall be deemed to be included in the VENDOR'S scope. The following additional points/tests shall also be considered as part of routine tests and included in the scope.

- Resistance must be measured at extreme taps also in addition to principal tap.
- Impedance must be measured at extreme taps also in addition to principal tap.
- No load loss and exciting current shall be measured at rated frequency at 90%, 100% and 110% rated voltage. These tests shall be done after impulse tests if the latter are specified.
- No load loss and exciting current shall be measured and recorded with 415V, 3-phase, 50 Hz input on LV side.
- Magnetic circuit (Isolation) test as per relevant standard.
- Measurement of zero sequence impedance

Type tests, if required, shall be carried out, as per applicable standards and the BIDDER shall quote extra unit prices for carrying out each of the type test.

In addition, if required, special Tests as listed below shall be carried out as per applicable standards and the BIDDER shall quote extra unit prices for carrying out the same.

- Partial Discharge test
- Acoustic Sound Level measurement
- Short Circuit Test
- Thermal Shock Test
- Environmental Test
- Climate Test
- Fire Behaviour Test

3.14 TEST AT SITE

- Preliminary checks
- Compare nameplate details with the specifications.
- Check for any physical damage, in particular of support insulators.
- Check tightness of all bolts, clamps and connecting terminals.
- Check cleanliness of support insulators, core coil assembly, marshalling panels, enclosure, etc.
- Check for clearances.
- Check earthing of transformer supporting structure/enclosure and neutral terminals.
- Check that the transformer is correctly installed with reference to its phasing and properly aligned with respect to switchgear and interconnecting external bus duct if any.
- Check for proper termination support of HV and power cables, and provision of cable glands for the same.
- Check welding/bolting to embedded parts/floor of the building.

The following tests/checks on dry type transformer shall be performed by the VENDOR at site at the time of erection and commissioning if included in scope. Typical checks to be carried out at site are listed below:

3.15 COMMISSIONING CHECKS (IF INCLUDED IN SCOPE)

- Insulation resistance test of windings and polarisation index on winding.
- Vector group test.
- Phase sequence test.
- Winding resistance test at all taps.
- Insulation resistance of control wiring.
- Core loss test at service tap.
- Voltage/turns ratio at all the taps.
- Magnetic current balance at full voltage.
- Capacitance and tan delta measurement.
- Tests on current transformers
- Continuity test
- Polarity test
- IR tests
- Magnetization characteristics
- Ratio test
- Secondary winding resistance measurement.
- Measurement of mV drop across HV and LV power connections and joints.

3.16 LOSSES

- Low Losses shall be as per ECBC 2017 latest amendments.

3.17 REJECTION

PURCHASER may reject any transformer if during tests or service (during warranty period) any of the following conditions arise:

- Total loss exceeds the guaranteed value.
- impedance value differs the guaranteed value by +/-10% or more.
- Winding temperature rise exceeds the specified value
- (d) Transformer fails on any High voltage tests.
- (e) Transformer is proved to have been manufactured not in accordance with the agreed specification.

The PURCHASER reserves the right to retain the rejected transformer and take it in to service until the VENDOR replaces, at no extra cost to PURCHASER, the defective transformer by a new acceptable transformer. Alternatively, VENDOR shall repair or replace the transformer within a reasonable period to the PURCHASER's satisfaction at no extra cost to the PURCHASER.

3.18 SPARES

The BIDDER shall quote item wise prices for the spares recommended for 3 years trouble free operation or as per the agreement between VENDOR and PURCHASER.

3.19 ON LOAD TAP CHANGING GEAR FOR TRANSFORMERS**3.19.1 SCOPE**

This specification covers on load tap changing gear (OLTC) for power transformers.

3.19.2 CODES & STANDARDS

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

3.19.3 REQUIREMENTS

OLTC over loading capability shall be compatible with the overloading capability of transformer as specified in relevant National/ International standard. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.

In case of on-load tap changer, the tapplings shall be on the high voltage winding. When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.

Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with the oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. An oil surge relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.

The OLTC switch contacts shall be located in a separate oil-filled chamber complete with its own oil preservation system, oil surge relay, shut-off valves, oil level gauge, gas vent, filling plug, drain valve with plug, dehydrating breather, oil sampling device inspection window with view glass. Oil, in compartments of OLTC which do not contain the make and break contacts,

shall be maintained under conservator head by valved pipe connections. Any gas leaving these compartments, shall pass through the oil surge relay before entering the conservator.

OLTC driving mechanism and its associated control equipment shall be mounted in an outdoor, weatherproof cabinet conforming to degree of enclosure protection IP55. The finish shall match with that of the transformer on which it is mounted. The cabinet shall include:

- On-load tap changer driving gear Motor shall be of squirrel cage totally enclosed type and shall comply with applicable Standard. It shall be suitable for direct starting and continuous running from 415 volts 3-phase or 240 volts single phase 50 Hz supply.
- Mechanically & electrically interlocked motor starting contactors with thermal overload relay, isolating switch and HRC fuses / MCCBs.
- Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa shall be provided in transformer cooler control cabinet / marshalling box and one no. out going feeder extending to OLTC DM cabinet, with appropriate provision for receiving the same.
- Control switch: Raise/off/lower (spring return to normal type) or independent push buttons.
- Emergency 'OFF' push button (stay put type).
- Provision shall be made for locking the new tapped position.
- Remote/local selector switch (maintained contact type).
- Mechanical tap position indicator.
- Tap changing switch shall be provided with make-before-break contacts with one fixed contact for each tap position.
- Limit switches to prevent motor over-travel in either direction and final mechanical stops.
- Appropriate scheme/device to permit only one tap change at a time on manual operation.
- Emergency manual operating device (hand crank or hand wheel).
- A five-digit operation counter.
- Space heaters with thermostat and HRC fuses / MCB.
- Control transformers with HRC fuses / MCBs on HV and LV sides for each supply.
- Interior lighting fixture with lamp, door switch/ ON-OFF switch and HRC fuses / MCB.
- Gasketed and hinged door with locking arrangement.
- Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
- Necessary relays, contactors, current transformers etc.
- Transducers or any other appropriate device for remote tap position indication.

OLTC shall be designed suitable for local manual as well as local electrical operation and Remote electrical operation including SCADA operation with provision of master follower scheme for parallel operation. The OLTC shall be housed in a separate tank so that oil of the OLTC chamber does not come in contact with the oil of main tank in any way. There shall be separate conservator with the arrangement of having the dehydrating breather for OLTC tank.

3.19.4 CONTROL REQUIREMENTS FOR OLTC

The following electrical control features shall be provided:

- Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
- Only one tap change from each tap change command even if the command is maintained.
- Cut-off of electrical control when manual operation is resorted to.
- Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
- Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

3.19.5 REMOTE CONTROL EQUIPMENT

The OLTC remote control equipment shall be housed in an indoor sheet steel cubicle to be located in a remote-control room. It shall conform to degree of enclosure protection IP42 or better and shall comprise the following:

- Control switch: Raise / Off / Lower (spring return to normal type) or independent push buttons.
- If automatic operation is specified, auto / manual selector switch (maintained contact type) and other items as required.
- If parallel operation is specified, master / independent / follower selector switch (maintained contact type) with 'out of step' annunciation.
- Tap position indicator.
- Facia type alarm annunciators with "accept", "lamp test" facilities and hooter / buzzer for alarms as required.
- Necessary auxiliary relays.

Lamp indications for:

- Tap change in progress.
- Lower limit reached.
- Upper limit reached.
- (Transformer cooler control apparatus conditions (if specified))

Cable glands for power and control cables.

240 V rated panel space heater with thermostat.

HRC fuses / MCBs.

Terminal blocks and internal wiring.

Earthing terminal.

Apparatus for control of transformer cooler equipment (if specified in relevant standard). The control and annunciation shall consist of Manual and Auto switch, indication of "On" condition of each pump and fan, and all annunciations related to cooler.

Each tap changing gear shall have two local selector switches: Remote-local and Electrical-Manual. OLTC shall normally be operated from DCS. All necessary control and monitoring features shall be available in DCS. Provision for various modes of operation of the tap changers of transformers like individual operation, remote DCS/local operation, etc. and for various interlocks shall be kept in the transformer local OLTC panel. Necessary equipment switches, relays, etc. shall be provided in this panel. Suitable I/O for interface with DCS shall also be provided. Any other feature desired for proper and safe operation of equipment shall be provided.

3.19.6 AUTOMATIC CONTROL OF OLTC

Automatic voltage regulator (AVR) for auto control of OLTC shall include:

- Voltage setting device
- Voltage sensing and voltage regulating devices
- Line drop compensator with adjustable R and X elements.
- Timer 5-25 seconds for delaying the operation of the tap changer for every tap change operation.
- Adjustable dead band for voltage variation.
- Additional features as required when parallel operation with other transformers is specified.

3.19.7 ALARMS

The following alarms shall be provided:

- A.C. supply failure
- Drive motor auto tripped
- Other protective purpose considered essential by the VENDOR.
- Out of step operation when paralleled transformers supposed to operate on the same tap are operating at different taps.
- Tap change delayed
- Tap change incomplete
- AVR failure (if AVR is specified)
- Transformer cooler fail (if specified)
- For all the alarms specified above a “OLTC trouble” group alarm to be provided in DCS which is located in control room.
- Others, as specified.

3.19.8 TESTS

Routine Tests

Routine tests as per relevant standards shall be performed on all OLTC's & Motor drive mechanisms. Over and above, Pressure and Vacuum tests shall be conducted as per relevant standards.

Type Tests

Type tests as per relevant standards shall be carried out on OLTC & Motor drive mechanism when called for. The bidder shall indicate in his price schedule extra price, if any, for carrying out these tests. Type test reports (not older than 5 years) for tests conducted on a similar OLTC & Motor drive mechanism shall be submitted for Consultants / Purchasers approval. If the bidder does not have type test reports, bidder shall carry out the tests without any cost implication to the Purchaser to prove the design integrity of the equipment without impacting the project schedule.

3.19.8 ADDITIONAL REQUIREMENTS

Tap position indicators and OLTC control switch shall be supplied loose if customer decides to mount the same in the power transformer control panel.

In addition to the items listed in this specification, the remote OLTC control panel shall be provided with apparatus required for control and monitoring of transformer cooling equipment if the same is asked in relevant standard.

The finish and dimensions of the panel shall be as specified so as to match with the other panels in remote control room.

3. RAISING MAINS & BUSDUCTS

SCOPE

This specification covers the design, material, construction features, manufacture, supply, inspection and testing at the VENDOR's/his SUB-VENDOR's Works, delivery to site and performance testing of Bus Bar Trunking (BBT) and accessories at site.

CODES & STANDARDS

The design, material, construction, manufacture, inspection, testing and performance of bus duct shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

GENERAL

The busbar trunking (BBT) system shall be of low impedance and sandwiched construction, i.e. no air gap shall exist between bus-bars except at plug-in opening.

It shall be possible to mount the BBT in any orientation, without affecting the current rating. The length of each section will be limited to max. 3 meters.

It shall be totally enclosed pre-painted galvanized steel and be of the non-louvered type maintaining an overall degrees of ingress protection as specified in Data Sheet.

BUSBARS

Busbars shall be of electrolytic grade copper / Aluminium as specified in Data sheet with purity not less than 99.9% and 99.9% conductivity for copper and >60% for Aluminium. The bus bar joints shall be silver plated copper/silver plated or tin-plated Aluminium. The busbars shall have rounded or radial edges.

Neutral shall be 100% of cross-sectional area of the phase conductor.

A continuous external earth busbar of material as specified in Data Sheet shall be provided.

Flexible connections shall be provided with Cu braided / multi leafed conductors for termination at both the ends

The busbars shall be individually insulated with by minimum 2 layers of insulating film.

Bus bar conductors shall be insulated with insulation Class F material or as specified in Data Sheet

All the insulation materials shall be halogen free, non-hygroscopic, high thermal conductivity and fire retardant.

HOUSING

The busbar trunking housing shall be totally enclosed, non-ventilated, natural cooled.

The enclosure shall be of hot dip galvanized and pre-painted sheet steel or Aluminium.

The housing shall be made of minimum 1.6 mm galvanized sheet steel / 1.6mm CRCA / 2.5mm Aluminium with an epoxy powder coated paint finish. It shall pass at least 1000 hours salt spray test to ensure the anticorrosion ability.

The housings shall be profiled, to provide higher strength, tested for IK-10 and efficient heat dissipation.

The width of the housings shall be preferably the same for all ratings of busbars, in order to provide interchangeability of tap off boxes.

Inspection cover shall be provided over joints to inspect the tightness of the connection.

Space heaters shall be provided in the BBT wherever the manufacturer considers required based on site conditions to prevent moisture condensation.

JOINTS

The electrical joints shall be of one to four bolt type designed for even distribution of contact pressure.

Bolts shall be accessible without removing covers.

The joints between sections shall be made so as to provide flexibility during installation and expansion / contraction of busbar during operation. The joints shall be of the Uniblock Joint. The joint construction must have the following features.

- a) Shear off nut: To ensure tightness of joint at desired torque.
- b) Tamper proof cap over shear off nut to prevent opening of nut after achieving desired torque.
- c) Heat expansion of atleast 3 mm per joint.
- d) The joint insulation must be of one-piece mould design and not have any cut edges which can absorb moisture.
- e) Joint assembly shall be removable as separate sub-assembly so that it can be inserted or removed without disturbing the adjacent sections.
- f) The busbars ends shall not have any holes or slots at the joints – the electrical continuity shall be through pressure plates, achieving a high area of joint cross section and expansion capability.

EXPANSION JOINT

Busbar expansion units shall be used in cases to reduce the stress on the system by differential expansion between the busbars and the casing; particularly for long run of the busbar.

It shall consist of a flexible joint in the middle on the conductors and a sliding casing in 2 sections which can absorb the relative movements of each section of the length.

TAP-OFF UNITS

Tap-off units of suitable rating shall be provided for bus trunking. Necessary provision for tapping on bus trunk at maximum 1 meter interval on one side & 0.5 meter interval on both the side shall be made on bus trunking.

Tap-off units shall be of dust and damp-proof version, degree of protection IP54 and sprinkler proof. Tap-off unit enclosure shall be same as the BBT enclosure.

Tap-off units shall be suitable for any brand of MCCB, shall be interchangeable, to suit site

requirements.

The tap off units shall have all safety features like mechanical interlocking so as to prevent installation or removal of the unit when the MCCB is in ON condition. Also, it shall not be possible to open the cover of the tap off box when the MCCB is ON.

Tap-off units shall be suitable for terminating armoured cables.

The plug-in tap-off units shall be connected to the busbar trunking whilst live via silver plated copper spring jaw connections.

The earth contact of the tap-off unit shall always be made before that of the live conductors and the last to break during removal. The tap off box shall be equipped with door isolating facility to carry out any maintenance of the circuit breaker without removing the tap off box from the main busbar system

Tap-off outlets shutter shall be able to open and close automatically when plug-in units are plugged in or removed.

The live parts or terminals inside the tap-off box unit shall be guarded with transparent visible sheet / insulated barrier to prevent accidental physical touch.

Bidder shall submit full discrimination charts for the selection of MCCB for the deployed BBT rating. The MCCB shall be current limiting type and the protection functions shall be as per SLD.

End Feed Unit / Centre Feed Unit:

End/Centre feed unit (EFU/CFU) with off load isolator / MCCB with RYB & ON / OFF/TRIP indications shall be provided as per indicated in SLD or as specified in Data Sheet.

Door interlock shall be same as per described for tap-off box.

EFU/CFU shall be suitable for termination of cables as per indicated in SLD.

Colour shade of tap-offs & EFU/CFUs shall be same as that of main bus trunking.

ACCESSORIES

The bus trunking system shall be complete with all the accessories such as straight run lengths, bends/elbows / flat elbow/ edge elbow/ T sections, vertical anchors, expansion joints, flexible connections, flange ends, reducer, end covers etc. All the accessories as required to suit site conditions are deemed to be included in straight length of the bus trunk.

Flanged end boxes shall be provided to accommodate flange end for connecting the bus trunking with flanges of panels, transformers & DG sets etc. At every terminal point at flanges the connection shall be done using flexible connections.

Any other item/ accessory not specifically mentioned above but deemed necessary by the bidder for successful implementation.

TESTS

All routine tests as specified in IS/IEC shall be conducted at the works and all site tests shall be conducted as per IS/IEC at site after the complete bus bar is assembled.

Certified copies of reports/certificates with final conclusions of type tests carried out as per relevant standards on similar type and rating of the equipment within last five years shall be furnished for review along with the Bid. Type test reports older than 5 years may be acceptable only if there were no change in relevant standard & manufacturer's product design and subject to purchaser's approval. In case the type test reports are not found to be meeting the specification requirements or older than five years with change in design, then

the VENDOR shall conduct all such tests free of cost and submit the reports for approval without any cost and time implication to the PURCHASER.

Type test assembly shall comprise of all the major components such as Insulations, joints, Tap-off units, etc., and shall depict the actual site installation. The components used in the type test assembly shall not be used in the bus bar sections being supplied for the project.

The busbars shall be type tested at a reputed national / International test laboratory (ASTA / KEMA / CPRI/ERDA/LOVAG) for short circuit withstand. The test shall be for a minimum duration of one second.

Degree of ingress protection (IP rating) shall also be tested at any reputed independent laboratory. This test shall be for IP54 / IP 55 for indoor and IP 65 / IP 67 FOR OUTDOOR application.

TYPE TESTS

The Bidder shall furnish type test certificate for the following tests conducted on similar equipment:

- a) Temperature Rise Limits
- b) Dielectric Properties
- c) Short Circuit Strength
- d) Degree of Protection

ROUTINE TESTS

Following routine tests shall be conducted on the Bus trunking:

- a) Physical verification check
- b) Megger Test
- c) Power frequency withstand test
- d) Any other tests as stipulated by the relevant standards

EXECUTION

Installation

The equipment manufacturer shall provide technical guidance during and/or following construction to perform a checkout of the system. At such time, factory-trained technicians shall carryout all necessary adjustments and instruct operating and maintenance personnel on the proper use and care of the system.

Any damage to BBT and its accessories during transportation / handling shall be immediately replaced by the VENDOR without any cost and time implication and the same shall be reported to the Purchaser.

The BBT and its accessories shall be properly supported on the truck or trailer by means of ropes to avoid any chance of damages.

DATA TO BE SUBMITTED BY VENDOR AFTER AWARD OF CONTRACT FOR APPROVAL

General arrangement with sections for BBT, tap off units, End feed units and centre feed unit.

Technical datasheet of BBT including all components.
Bidder's Stamp & Initials

Itemised Bill of material for complete BBT covering all the components and accessories along with the rating.

Details of joints between sections, expansions joints and terminal connections.

Quality assurance plan and Testing procedures

FOR INFORMATION

Copies of instruction manuals to cover installation, commissioning, operation and maintenance

1.	BUS BAR TRUNKING	✓ IEC 61439 -6 / IS 8623
2.	DEGREE OF PROTECTION	✓ IEC 60529
3.	FIRE RATING	✓ (ISO 834) 55

4. LT PANELS

Selection Criteria of LT Panels :

LT panel shall be metal clad, self standing dust proof construction, indoor cubicle type fitted with ACB/MCCB which has inbuilt metering, communication facility, drawout/fixed type. Degree of protection of indoor LT panel shall be IP4X and outdoor panel shall be IP55, complying to form 4b.

All the panel submittals like drawings, schematics, BOM, bus bar sizing calculations, technical datasheet, any other calculations, test reports, etc. shall be sealed by signed by OEM (ABB, Schneider, Siemens, Legrand). The submittals without seal and sign by OEM will not be accepted.

Main LT panel and DG Synchronizing panel shall be internal arc tested as per IEC 61641 and totally type tested (TTA) as per IEC 61439 OEM design. All other panels shall be partially type tested (PTTA) as per IEC 60439. For LT panels feeders rated above 630A, ACB shall be used. For all other feeders MCCB shall be used. All major component inside the switchgear shall be from the same OEM only.

Total selectivity for Reliability & Availability: Panel supplier and Switchgear Manufacturer must ensure total selectivity between Upstream and Downstream Breakers (ACB, MCCB) for entire electrical distribution network (i.e. right from Final Distribution Board and MCC, till the Main LV Panel). If required, Panel builder and switchgear manufacturer shall use higher incomer breaker ratings to achieve total selectivity w.r.t downstream Breaker. Switchgear manufacturer shall submit Total Discrimination report along with vendor drawing.

All terminations using suitable PIN or eye type tinned copper lug duly crimped. All circuits shall be labelled using ferrules.

Meters in the switchboard shall comply with IEC 61557-12: "Electrical safety in low voltage distribution systems up to 1000V a.c. and 1500V d.c. – Equipment for testing, measuring, or monitoring of protective measures – Part 12: Power metering and monitoring devices (PMD).

Metallic barriers should be used to achieve desired IP rating rather than HYLEM sheets.

Minimum IP 20 should be met even with LT panel door open. All live bus bars terminals shall be shrouded.

The Rated impulse withstand of the LV assembly shall be equal to or greater than the rated impulse withstand of the ACB's and MCCB's .

All LT switchgear shall be from same make. Different make of LT panels is not acceptable.

Type test/ design verification certificates shall be from IEC authorized third party independent certification bodies and not from testing laboratories.

All ratings of feeder used in the switchgear shall be tested as per IEC 61439& IEC60439.

The status of all breakers and meters shall be integrated with BMS. Gas flooding system will be used for Main LT panel and fire panel.

Status monitoring of the breaker ACB & MCCBs shall be selected shall be Communicable type on Modbus TCP/IP for BMS/SCADA integration in future.

All ACB shall be supplied with inbuilt earth fault release. External earth fault release will not be accepted. ACB shall be with integral Modbus TCP/IP communication feature.

MCCBs rated upto 100A shall be provided with TMD release. Above 100A & less than 200A shall be TMA based. 250A & above shall be with microprocessor release. All MCCB at incomers and main panel out goings shall be provided above 250A shall be Microprocessor

based with Overload, short circuit and Ground fault protections. All other MCCB outgoing power feeders shall be with Overload, short circuit release.

All panel incomers shall be provided with earth fault release.

Control supply required for all LT panel Breaker Close, trip, Numerical relays, contactors, auxiliary relays, annunciations, etc., shall be catered by means of UPS system. Bidder to consider required UPS DB, cabling, etc in his scope. Cost of UPS DB, cabling from UPS DB to panel shall be included in the respective panel cost itself.

The material of busbar shall be Copper for all panels. Current density for copper shall be 1.25 A/Sq.m or as per OEM design Standards. This will be followed for all busbars including busducts, transformer terminals, panel bus bars, etc.

The rating indicated in the SLD is indicative only the vendor has to select the suitable rating of protective device based on the discrimination chart during detailed engineering stage without any price implication. If any breaker rating is changed due to discrimination study no additional cost shall be paid. Discrimination study report shall be shared to consultant/client for review and approval.

The conductivity bus bars should high and electrolytic grade copper of 99.9% IACS (International annealed copper standard) confirming to IS 5082 – 1981.

The main LT Switchgear which is fed from the transformers shall be provided with SPDs and necessary switching devices of adequate rating.

The thickness of the load bearing members shall be 2 mm and the non-load bearing members shall be 1.6mm.

Panel height shall be limited to 2.1m or 2.4m maximum as per type tested design.

The panel shall be designed to suit to the site condition. If any U shape/L shape panels required as per site requirement, contractor to consider all required dummy panel, adaptor boxes, bus bar extension, other accessories, etc. in the panel cost itself. No additional payment will be provided for the same.

Electronic Multifunction meters with communication port (3 phase Current, 3 phase Voltage, KW, KWH, KVA, PF, Hz, KVA_r) with 0.5 class accuracy shall be provided as per SLD. Multifunction meters shall be EMC compliant, four quadrant type.

Digital Multifunction Meter (MFM) in DG synchronising panels and main LT panels shall be provided with (but not limited to) following metering features: Current, Voltage, Frequency, Energy (KWH), MD (KW/KVA), PF, KVAH, KVAR, KVARH, V THD, I THD, etc. ALL MFM shall be provided with Modbus protocol and same shall be communicated to BMS

Overload protection by thermal (bimetal) relays in all the three phases to trip. The thermal overload protection relays will have built in protection against single phasing

Short circuit protection in the three phases through breakers (MPCB/MCCB). All MPCB, MCCB shall be provided with breaker operating handle and it shall be capable of operating without opening the door.

Motor Modules up to 50 kW, the starter shall comprise of contactor and MPCB with inbuilt thermal overload.

Motor Modules above 40 kW and up to 100 kW, the starter shall comprise of contactor and MCCB with discrete thermal overload through bimetallic relay.

Motor Modules above 30kW shall be provided with 240V single phase space heating arrangement.

All protective equipment ratings for motor feeders shall be as per type-2 coordination chart.

Local start / stop push button stations lockable in stop position will be provided for all motors as per system requirement.

Motors rated upto 5.5 kW DOL starters will be provided. Motor rated above 5.5kW Start delta starter will be provided. However, incase system requirement demands for VFD starter, VFD will be provided.

The panels where more than one incomer is shown, bidder to consider all necessary Line voltage monitor (LVM), contactors, Auxiliary relays, etc. required for auto changeover arrangement.

For Main LT panel-1 & 2, If there is no power in EB incomer, the DG incomer shall close automatically. On restoration of EB power, the DG incomer shall be tripped and EB incomer will close automatically. Bidder to consider all necessary Line voltage monitor (LVM), contactors, Auxiliary relays, etc., in his scope. The cost shall be included in the respective LT panel cost itself.

When DG is switched on the loading on DG shall be in gradual manner. Electrical contractor should coordinate with DG contractor for the loading Patten. The switching on of loads shall be as per DG contractor requirement. Electrical contractor shall consider all necessary timers, contactors, controllers, Auxiliary relays, etc. in his scope. The cost of such items shall be included in the panel cost itself.

Gland plate thickness shall be 3mm

OPERATION & CONTROL PHILOSOPHY

All Panels shall be controlled locally at switchgear level. The status of breakers (On/OFF/Trip) & metering values shall be monitored from BMS.

All LT breakers shall be connected to monitoring module thro hardwired cables. The meters will be connected to the monitoring module via soft link (Modbus). The maximum number of meters connected in single loop will be limited to eight (8). The maximum breakers connected to each monitoring module will be decided by the vendor based on the model selected. Minimum one monitoring module will be provided for every panel.

All monitoring module will be looped using the TCP/IP protocol. The monitoring module will be connected to Ethernet switch/FRTU via redundant link.

Detailed Architecture shall be submitted by the Bidder.

All main LT panels and sub panels incomer and outgoings shall be interfaced with BMS.

All the cost required for BMS integration like FO cable, control modules, PLC, converters, connectors, switches etc as per the attached scheme shall be included in panel cost itself.

DETAILED SPECIFICATIONS:

GENERAL

This specification covers the design, material, construction features, manufacture, inspection and testing at VENDOR's/SUB-VENDOR's works, delivery to site and performance testing of metal enclosed Low Voltage switchgear for voltage not exceeding 1000 V A C

CODES AND STANDARDS

The design, manufacture, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied. Nothing in this specification shall be construed to relieve the VENDOR of his responsibility. In case of conflict between these standards and this

specification, more stringent of the two requirements shall govern. Some of the currently applicable standards are indicated in Data Sheet.

All codes and standards referred to in the specification shall be understood to be the latest version on the date of offer made by the Bidder unless otherwise indicated.

The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

CONSTRUCTIONAL FEATURES

The major parameters of the switchgear and other required features are given in Data sheet - . The bidder shall in his offer specifically confirm compliance of these data in full. Deviation if any should be specifically brought out in the schedule of Technical Deviation.

The switchgear shall be indoor, metal enclosed, floor mounted of uniform height not more than 2450 mm, made up of the requisite vertical sections, dust and vermin proof construction with IP - 52 degree of protection, unless otherwise stated in Data Sheet. The degree of protection provided by enclosures against external mechanical impacts shall be IK08 minimum. Panels shall be supplied with base channel (Minimum ISMC 75/ 100) which will be an integral part of the panel.

Adjacent switchgear cubicles shall be provided with side sheets on either side to ensure complete isolation. The switchgear shall be easily extendable on both sides by the addition of vertical sections.

From internal isolation point of view, the switchgear shall be designated in the following form of separation:

- Form 1 : No internal separation
- Form 2 : Separation of busbars from the functional units
- Form 2a : Terminals not separated from bus bars
- Form 2b : Terminals separated from bus bars
- Form 3 : Separation of busbars from the functional units
Separation of all functional units from one another
- Form 3a : Terminals not separated from bus bars
- Form 3b : Terminals separated from bus bars
- Form 4 : Separation of busbars from the functional units
- Form 4a : Separation of all functional units from one another
- Form 4b : Separation of terminals from those of any other functional unit

Please refer Data sheet /BOQ for the specified form of separation

The bottom of the switchgear shall be fully covered by sheet steel.

Removable gland plates shall be provided for power and control cables. The gland plates shall be 3mm thick for panel with circuit breaker cubicles (ACB/ MCCB) and 2mm thick for other cubicles. The gland plates for single core cables shall be of non-magnetic material.

The Painting shall be carried out with Powder coating which includes following main activities:

- (a) Panel shall be complete with all fabrication work like drilling, punching, shearing and welding etc. before proceeding to pre painting processes.

- (b) Pre-treatment of all sheet steelwork, including degreasing, acid pickling, de-rusting, phosphating, passivation including repeated rinsing in between each process shall be carried out as per applicable standard.
- (c) After Pre-treatment, the panel shall be provided with protective coating including compatible primer with the shade as indicated in Data Sheet for exterior and interior with minimum thickness of 80 microns DFT.
- (d) After coating, Curing shall be carried out as per the required process. Any post painting fabrication activity like drilling, cutting, welding may liable for rejection of complete panel

Each switchgear cubicle shall be fitted with a label in the front and back of the cubicle. Each switchgear shall also be fitted with label indicating the switchgear designation, rating and duty. Each relay, instrument, ACB, MCCB, switch, fuse and other devices shall be provided with separate labels. These shall be with Aluminium anodized / 3 ply Lamicold/ Acrylic name plates (with white letters on Black background) at front, inside & rear side

Operating devices shall be incorporated only in the front of the switchgear. No equipment needing manual operation shall be located less than 300 mm or more than 1800 mm above ground level.

The switchgear shall be divided into distinct vertical sections comprising of:

Individual feeder module which shall be integral multiples of basic module, containing all associated equipment, enclosed in sheet steel enclosure on all sides and the rear except cable alley side and provided with hinged door on the front. Cable alley side of the feeder enclosure shall be as per the Form specified in Data Sheet

A completely metal enclosed, busbar compartment running horizontally, and a vertical busbar compartment serving all modules in vertical section.

Wherever a vertical cable alley covering the entire height except horizontal busbar compartment is provided, the width shall be minimum 300 mm with adequate number of slotted cable support arms.

A horizontal separate enclosure or enclosures separated by Hylam/FRP sheets for power and control buses with tap off connections to each vertical section.

The exposed bus / live parts in the cable alley shall be totally covered against accidental contact by a shroud (not by PVC sleeve) to protect the workmen working on the switchgear

The circuit breakers shall be fully draw out type if specified In Data Sheet /SLD. These circuit breakers shall have distinct service, test, isolated and maintenance positions. In the test position the circuit breakers shall be capable of being tested for operation without energising the power circuits. Four normally open auxiliary contacts shall be provided for each of the services and test limit switch positions.

The test position should preferably be obtained without the need to disconnect normal control connections and use extension cords for testing.

The current transformers shall be mounted on the fixed portion of the switchgear but not directly on buses or the breaker truck.

The chassis housing feeder for motor control equipment except circuit breakers/common control transformers of big size, shall be of the fully draw-out, semi-draw-out, or fixed type as specified in the Data Sheet.

Fully Drawout Type Withdrawable Chassis

In this type of construction, it shall be possible to drawout the withdrawable chassis without having to unscrew or unbolt any connections to the equipment mounted on the withdrawable chassis. The power and control drawout type connections shall be of the stab-in or sliding type. All drawout contacts, including for auxiliary and control wiring shall be of self-aligning type.

Semi-Draw-out Type Withdrawable Chassis

In this type of construction, it shall be possible to draw-out the withdrawable chassis after manually unplugging at the terminal blocks the control circuit connections of the equipment mounted on the withdrawable chassis, without having to unbolt any power connections of the equipment. The power connections shall be of the stab-in or sliding type and shall be disconnected when the chassis is withdrawn.

Fixed Type Withdrawable Chassis

In this type of construction all power connections to the equipment mounted on the withdrawable chassis shall be of the bolted type. All control circuit connections to equipment mounted on the withdrawable chassis shall be carried out through conventional terminal blocks mounted in the respective chassis. It shall be possible to draw-out the chassis after unbolting/ unscrewing all the power and control circuit connections to the equipment mounted on the withdrawable chassis.

All identical equipment and corresponding parts including chassis of drawout modules of the same size shall be fully interchangeable, without having to carry out modifications.

The draw-out contacts shall be made of copper/ copper alloy/aluminium faces, which shall be silver or tinplated.

If ventilating louvers are provided, they shall be provided with fine-screened brass or GI meshes from inside to prevent entry of vermin and dust

MODULE TYPES

The various types of modules indicating the control requirements of each type, together with the list of component equipment required for each type are detailed in the standard drawings. These are as follows:

- A - Incoming circuit - Isolating switch and fuse.
- B - Incoming circuit - Circuit Breakers.
- C - Incoming circuit - Isolating switch.
- D - Voltage transformer circuit.
- E - Outgoing feeder - Circuit breaker.
- F - Outgoing feeder - Switch-fuse unit controlled.
- G - Bus coupler
- H - Auxiliary services - Common equipment for Annunciation scheme
- J - Auxiliary services - Common equipment for Space heater supply
- K - Motor control - Direct-on-line-non essential motors
- L - Motor control - Direct-on-line essential motors
- M - Motor control - Automatic Star-Delta motor (Open-transition)
- P - Motor control - Automatic Star-Delta motor (Close-transition)
- R - Motor control - Reversing control

Motor control modules are further differentiated by suffixes as described below, unless otherwise stated in Data Sheets-A3.

Suffix in Denotation	Suffix in	Denotation
First	(Control	second
		(Motor kW

<u>Digit</u>	<u>location)</u>	<u>digit</u>	<u>rating range)</u>
1	Controlled from MCC	1	Up to 30 kW
		2	31 - 49 kW
		3	50 -125kW
		4	above 125 kW
2.	Controlled remote from MCC	1	Up to 30 kW
		2	31-49 kW
		3	50-125 kW
		4	above 125 kW

MAIN AND AUXILIARY BUSES

Busbars shall be of uniform cross section throughout the length of the switchgear, and up to the incoming terminals of the incoming feeder circuit breaker/ switch. Busbars shall be of Aluminum or Copper as specified in Data Sheet / SLD

All busbars shall be provided with heat shrinkable type PVC sleeves, all bus taps, joints shall be insulated with moulded caps. If insulating sleeve is not colored, busbars shall be color coded with colored bands at suitable intervals.

Busbars shall be adequately supported on insulators. These shall withstand dynamic stresses due to short circuit currents specified.

Auxiliary Buses

Auxiliary buses for control power supply, space heater power supply or any other specified service shall be provided. These buses shall be insulated, adequately supported and sized to suit specific requirements. The material of control power supply buses shall be electrolytic copper. The material for space heater power supply buses shall be same as that for the main power buses. Supply transformer(s), auxiliary busbars and necessary connections to the supply transformers and associated circuits shall be in the VENDOR'S scope,

The bus-bars shall be designed considering the following criteria:

- (a) Sleeving made of insulating material on all bus bars.
- (b) Site ambient and final temperature of the bus-bars as specified in Data sheet-.
- (c) Bus bars being inside the panel - duration for enclosure and ventilation.
- (d) Bus bars carrying rated current continuously.
- (e) Configuration of bus bars and Proximity effect
- (f) Bus bars shall withstand the short time rating of the panel for given duration
- (g) Main Horizontal bus-bars of PCC above 4000A with Copper bars shall be interleaved type if required
- (h) The Bidder shall furnish calculations establishing the adequacy of the bus bar sizes to meet the continuous and short time current ratings specified for approval before manufacturing

Bus bar supports shall only be SMC irrespective of bus bar size. The span between the two insulators shall be as per the approved type test report for short time rating. Joint positions and insulators shall be properly adjusted so that they don't interfere. Bus bar bending shall be carried out on appropriate machines designated for the same rather than doing manually

All bus-bar shall be treated with anti-oxide paste wherever bi-metallic contact is required

Size of the vertical busbars in each vertical section shall be such that it shall carry minimum 80% of the sum of the connected load to that vertical bus

BIDDER shall ensure that incoming feeder shall be suitably designed for terminating the required no. of runs of 1.1kV grade XLPE insulated armoured cables with 20% spare capacity. BIDDER shall consider the necessary arrangement (dummy panel, adapter panel, rear extension etc.) if required, for terminating the cables.

In case of busduct termination at the incomer, flange arrangement as per requirement of busduct Vendor shall be considered. Phase crossover arrangement shall be considered if specified in Data Sheet

Neutral bus-bars of different panel boards shall be as indicated in the corresponding SLDs

DP MCB shall be provided for all control circuits where the fault level is less than fault withstand capacity of MCB. Else the control supply shall be tapped through a control transformer of adequate capacity supplied with MCCB/ MPCB / SFU of adequate short time rating. Independent DP MCBs shall be provided for each circuit such that tripping due to fault in one circuit should not affect other functions adversely. The insulation class for control transformer shall be Class B

Where control transformer has been provided, a separate control bus shall be run maintaining adequate clearance of atleast 300mm from the power bus with provision of tapping at each vertical column section. The control bus should be preferably a bus bar with Heat shrinkable sleeve

All electrical panels (internal components & arrangement) shall have finger touch protection, for human safety viz. working on one component shall not cause shock to the personnel due to any other live component in the panel. Also, the terminal live parts shall not be accessible by fingers (finger cannot come in contact with live parts of the terminals)

No openings/ holes meant for fixing hardware shall be left open. All the hardware (esp. screws, nuts, bolts, and washers) shall be in all appropriate positions & properly tightened

Phase separators, shrouds, falling tool barriers shall be suitably provided. Any additional requirements as observed at any stage up to handing-over shall be provided (for safety and ease of maintenance)

SAFETY INTERLOCKS AND FEATURES

Withdrawal or engagement of circuit breakers or switch (isolator) shall not be possible unless it is in the open position.

Operation of circuit breaker shall not be possible unless it is fully in service positions or in test position or is fully drawn out.

Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the exposed live parts when the breaker is withdrawn.

Caution name plate with inscription "Caution - Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, e.g. incoming terminals.

A breaker of given rating shall be prevented from engaging with a stationery element of higher rating.

Padlocking provisions shall permit locking the circuit breaker in either the "test" or "disconnected" position

Each door and cover shall have adequate reinforcement of suitable ribs and stiffeners from inside. All doors shall be with concealed type hinges and captive screws. Side covers of panels shall be with removable panels. Rear doors of panels requiring rear access shall be provided with removable hinged doors.

All door locks shall be provided with special keys to ensure opening by authorized personnel only

Feeder shall have hinged openable (more than 90°) type door with panel locks. All bus-bar covers and other panel covers shall be screw fixed.

Etched Aluminium Caution boards for 433V written in three languages (English, Hindi and Marathi) shall be riveted on the panel on all four sides at locations where live bus bars are present and need isolation before any access to it. In case secondary covers have been provided inside the panel, then caution boards shall be also marked on these boards in addition to the external covers. Stickers are not acceptable.

Feeder and board name plates to be provided at front and rear of switchboard

Stud type terminals and ring type lugs shall be used for control cables

Equipment nameplates shall be fixed by screws/ rivets and shall not be pasted.

Drawing pocket shall be provided on the inside of incomer feeder door. Self explanatory wiring diagrams with terminal and wire numbers, component numbers shall be provided on the inner face of the door of each feeder. Drawing set in the panel shall be laminated

All hardware e.g. Nuts, bolts, gasket, anchor fasteners, etc, are included in the Bidder's scope. Atleast 10% extra hardware shall be considered for any installation/fixing work. This is to ensure ready availability of hardware in case of loss of some hardware during installation. All hardware shall be hot dip galvanised.

Gaskets shall be EPDM type

All PVC/ engineering plastic based items (including but not limited to trough, trunking, enclosures, covers, plugs, etc) shall be with FR properties

The Vendor shall supply switchgear in various shipping sections comprising incomer, etc. Maximum single shipment section shall not be more than 2000 mm in length. Lifting hooks/ eyes shall be provided in each shipping section of the equipment and shall be removable type

Breaker up to 1600A shall be installed in two tiers and above 1600 A, it shall be mounted in single tier unless otherwise specified in Data Sheet

Panel shall be Salt spray tested for minimum duration of 500 hours if specified in Data Sheet

Component mounting plate thickness shall be minimum 2.0mm

The current transformers shall be mounted on the fixed portion of the switchgear but not directly on buses or the breaker truck.

All identical equipment and corresponding parts including chassis of drawout modules of the same size shall be fully interchangeable, without having to carry out modification

AIR CIRCUIT BREAKERS

The air circuit-breakers are constructed and tested in accordance with the international IEC/EN 60947-2 standards. The breaker shall provide the class II insulation between front panel and internal power circuits to avoid an accidental contact with the live main current carrying path with the front cover open.

ACB shall be with 55KA minimum breaking capacity and as per KA rating mentioned in SLD.

Circuit breakers shall be provided with following accessories:

Accessories as asked in Data sheet -

Mechanically operated targets to show 'Open', 'Closed', 'Service' and 'Test' positions of the circuit breaker. Padlock devices shall be provided in order to control opening/closing and racking in/out of the circuit breaker

Mechanically operated, red 'trip' push button, shrouded to prevent accidental operation. Circuit breaker main contacts should be separate from arcing contacts

Locking facilities in the 'Service', 'Test', and 'Isolated', positions. In test position the breaker will be tested without energizing the power circuits. The breaker shall remain fully housed inside the compartment in the test position. Complete operation of the circuit breaker and trip unit must be accessible without opening the circuit breaker door

Minimum 6 NO and 6 NC potential free auxiliary contacts, rated 10 A at 240V AC and 1A inductive breaking at 220 V DC

Following indicating lamps for ACBs shall be considered :

- (a) On
- (b) Off
- (c) Trip
- (d) Test Position
- (e) Service Position
- (f) Spring Charged
- (g) Trip Circuit healthy
- (h) Control Supply Healthy

R, Y, B indication lamps, Lamp test push button, Emergency trip push button shall be considered at incomers.

Trip shall be independent of local/remote. Emergency trip push button shall be mushroom type with lockable key

Closing and trip coil shall operate satisfactorily under the following conditions of supply voltage variation:

- (a) Closing coils - 85% to 110% of rated voltage.
- (b) Trip coils - 70% to 110% of rated voltage.

When series trip circuit breakers are specified the following micro processor releases with adjustable settings shall be provided:

- (c) Overload
- (d) Short circuit
- (e) Under voltage
- (f) Earth fault

For four pole breaker the microprocessor based earth fault release shall be in built. For TPN breaker the microprocessor based earth fault release shall be in built with input from a separate neutral CT.

The circuit-breakers shall have a rated service voltage of 690 V AC and a rated insulation voltage and impulse withstand voltage 1000 V & 12 kV respectively;

In addition to the adjustable current setting range specified in the Data Sheet- short circuit releases shall be provided with at least four adjustable time delay settings, If it is not possible to provide the specified adjustable current setting range for the short circuit releases, shunt trip circuit breakers together with necessary protective relays shall be offered by the VENDOR.

Facilities shall be provided for blocking the under-voltage release, if so required at Site.

Each of the foregoing releases shall be provided with a single pole, double throw, potential free alarm contact rated for 0.5A, 220V D.C / 10A, 240V AC.

The breakers controlling motors shall operate satisfactorily under following conditions:

Bidder's Stamp & Initials

- (g) Direct-on-line starting of the specified motor.
- (h) Breaking no load current of the specified motor.

SPRING OPERATED MECHANISM

The operating mechanism shall be manually operated spring charging stored energy type or with motor, opening and closing springs, limit switches for automatic charging and all necessary accessories. Facility for manual charging of the closing spring shall be provided. The operating mechanism shall be trip-free and non-pumping electrically.

Power operated mechanism shall be provided with facilities for remote panel closing and opening operations whenever specified in Data Sheet-A3 as per breaker module designation and respective enclosed control scheme drawings if attached.

The control scheme will be as follows for remote control:

Sl.No.	Breaker Position	Service		Test	
	Selector Switch	Local	Remote	Local	Remote
(i)	Switchgear Protection Tripping	Yes	Yes	Yes	Yes
(j)	Remote Interlock Tripping	Yes	Yes	-	-
(k)	Switchgear Manual Closing	-	-	Yes	-
(l)	Remote and Auto Closing through Interlocks	-	Yes	-	Yes
(m)	Switchgear Manual Tripping	Yes	-	Yes	-
(n)	Remote Manual Tripping	Yes	Yes	-	Yes
(o)	Local P.B. Station of Motor (For breaker Operated motors)				
	(i) Closing for trial run	Yes	-	-	-
	(ii) Tripping	Yes	Yes	Yes	Yes

Power operating mechanisms shall be provided with the following additional features:

- (a) Closing of the circuit breaker shall automatically initiate recharging of the spring ready for the next closing stroke.
- (b) The motor shall be mechanically decoupled as soon as the emergency manual charging handle is coupled.

All ACBs shall be with $I_{cu}=I_{cs}=I_{cw}=100\%$

Incomer ACB shall be with Modbus/TCP IP communication facility.

All EDO ACB's shall have ready to close contact to ensure that ACB gets a command only when it is ready to close for applications of remote control, AMF, synchronization and auto source change over systems.

All terminals shall be changeable from horizontal to vertical position and the vice versa at site to suit the bus bar orientation if required

Bidder's Stamp & Initials

All ACBs should be of same family. Mixing of series is not allowed.

PROTECTION COORDINATION

It shall be the responsibility of the Vendor to fully coordinate the overload and short circuit tripping of the circuit breakers with the upstream and downstream circuit breakers/fuses/motor starters, to provide satisfactory discrimination. Protective releases shall be EMC compliant. The release shall be protected against non-linear loads and shall not cause nuisance tripping due to harmonics. All protective components esp. ACBs and MCCBs installed in PCC and at Incomer of downstream Panels shall be with Utilisation Category "B" (i.e. offering time discrimination with downstream devices)

Protection Releases

The trip unit should be able to give the following minimum features:

Overload protections with IDMT characteristics

Short circuit protections (both IDMT & DMT)

Instantaneous protections

Ground fault protections

Current Unbalance protection settable from 2 to 90% In unbalance

Making on short circuit protection

Time delayed Over current protection from 0.6 to 10 X In

ACB release shall be upgradable without changing hardware.

It shall be possible to upgrade the protection and measurement functions of the trip unit with digital software packages without any hardware modifications to ensure the customization and upgrading at any point of time during the life cycle of the breaker.

The protection release shall be suitable for communication via in-built Modbus TCP for all ACBs, without using any additional external device or protocol converter. It shall be compatible for integration into SCADA system.

All circuit breaker settings and functions are also accessible via Bluetooth, using free mobile app.

This remote connection allows a safer interaction with the device mitigating the risk of arc flash accidents.

The releases shall be suitable for zone selectivity without any external device and shall be part of breaker protection unit.

AIR BREAK SWITCHES

Air break switches shall be of the heavy duty, group operated load-break, fault-make type, complying with the requirements of applicable standards mentioned in Data Sheet

Whenever solid link are used for the connections between switches and fuses, such links shall be fitted with insulated sleeves. Whenever the links are of less than 100 mm length where sleeves cannot be fitted, taping is acceptable.

All live parts of the switch shall be shrouded.

Switch operating handle shall be suitable for padlocking in 'OFF' position.

It shall be possible to open the door only when the switch is in the 'off' position.

Suitable means shall be provided to intentionally release the interlocks specified in the preceding clause 6.6 for making trip setting adjustments and operation tests.

FUSES

Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of not less than 80 kA at 440V.

Fuses shall be provided with visible indication to show that they have operated.

Fuse ratings chosen by the VENDOR for application in various circuits shall be subject to the PURCHASER'S approval.

Fuses shall preferably be mounted in moulded plastic carriers and shall be complete with fuse bases.

Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type of bases. In such cases an insulated fuse pulling handle shall be provided for each size of fuse for each switchboard.

Current time characteristics of fuses shall be furnished along with bid.

MOTOR STARTERS

CONTACTORS

Motor starter contactor shall be of the electromagnetic type rated for uninterrupted duty as defined in applicable standards unless otherwise specified in Data Sheet.

Operating coils of contactors shall be suitable for operation from the control supply system specified in Section-B or as per control schemes if enclosed. Operating coils shall be of the low burden type if specified in Data Sheet

Class of coordination for starter module shall be Type '2'.

DIRECT-ON-LINE STARTERS

Direct-on-line starters shall be suitable for Class AC 3 utilization category as specified in applicable standards, unless otherwise mentioned in Data Sheet.

AUTOMATIC STAR-DELTA STARTERS

Automatic star-delta starters shall comprise three sets of contactors one for the line, one for the star point and one for the delta, and a timer to automatically change the connections from star to delta.

Star-delta contactors shall be electrically interlocked to permit starting of the motor in the proper sequence, namely star contactor closing, line contactor closing, timer energized after time delay, timer contact de-energizing the star contactor, and delta contactor closing.

Star-delta starters shall be suitable for AC 3 utilization category as specified in applicable standards, unless otherwise mentioned in Data Sheet.

The Star-delta starters shall be with open or closed transition as specified in Data Sheet

REVERSING STARTERS

Reversing starters shall comprise forward and reverse contactors, electrically interlocked with each other.

Reversing starters shall be suitable for Class AC 4 duty as specified in applicable standards, unless otherwise mentioned in Data Sheet.

THERMAL OVERLOAD RELAYS

Starters shall be complete with a three element, positive acting, ambient temperature compensated, time lagged thermal overload relay with adjustable settings and built in single phasing preventer. The setting range shall be properly selected in accordance with the rating of the motor.

Thermal overload relays shall be hand reset type, unless otherwise specified in Data Sheet.

'Stop' push button of the starter and hand reset device shall be separate from each other.

Overload relay hand reset push button shall be brought out on the front of the compartment door.

SWITCH AND CONTACTOR RATINGS

Switch and contactor rating for various motor starter modules shall be selected by the bidder and indicated in the bid. BIDDER shall also select appropriate ratings for HRC fuses and

ranges for thermal overload relays and indicate the same in the bid. These details shall be subject to the PURCHASER'S approval.

MOULDED CASE CIRCUIT BREAKERS (MCCB)

Moulded-case circuit breakers (MCCB) must be designed, constructed and tested according to IEC 60947-1, IEC 60947-2 or to the corresponding harmonized Standards.

Moulded case circuit breakers (MCCBs) shall be provided when called for in Data Sheet-/SLD, for use in lieu of switch-fuse for the motor controls. The MCCBs shall conform to the latest applicable standards.

Electrical characteristics:

Rated voltage U_e – 690VAC

Rated Insulation voltage U_i – 1000V

Impulse withstand voltage U_{imp} – 8KV

Frequency: 50 – 60HZ

MCCBs in AC circuits shall be of triple/four pole construction arranged for simultaneous three/four pole manual closing and opening as indicated in Data Sheet /SLD. If indicated in Data Sheet-, power closing device for remote operation shall be provided. Operating mechanism shall be quick-make, quick-break and trip-free type. The ON, OFF and TRIP positions of the MCCB shall be clearly indicated and visible to the operator. All MCCBs shall be provided with rotary operating handle with door interlock feature

The instantaneous short circuit release shall be so chosen by the VENDOR as to operate at a current in excess of the peak motor inrush current and a range of settings shall be provided for the PURCHASER'S selection.

MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.

All MCCB feeders shall be provided with ON/OFF/TRIP indicating lamps through auxiliary contacts.

All MCCB's shall be with $I_{cu}=I_{cs}=100\%$. All MCCBs should be of same family. Mixing of series is not allowed.

All MCCBs shall be provided with 2 NO + 2 NC aux. contacts exclusively for Purchaser's use or as specified in Data Sheet

All the MCCBs shall be of current limiting type and shall provide a cut off in, < 10 ms for prospective currents during faults.

The MCCB's shall be provided with thermal magnetic or microprocessor-based overload, short circuit and earth fault releases as specified in Data sheet . For four pole MCCB the microprocessor-based earth fault release shall be inbuilt. For TPN MCCB the microprocessor-based earth fault release shall be inbuilt with a separate neutral CT input or the earth fault protection shall be provided by CBCT, ELR and shunt trip coil. For thermal magnetic release the earth fault protection shall be provided by CBCT, ELR and shunt trip coil.

Protections:

Microprocessor based protection

-MCCBs from 200A to 630A shall be microprocessor-based with LSIG Protections. -The Trip Unit shall have individual fault Indication LEDs for easy identification of MCCB Tripping Fault.

Thermal magnetic protection

-MCCBs upto 200A shall be Thermo-magnetic based with Overload & Short Circuit Protections.

-The protection threshold against overload must be adjustable starting from 0.7 times the rated current of the trip unit and up to its rated value.

-Adjustable thermomagnetic trip units from rated current from 80A to 200A shall have magnetic setting adjustable from 5 up to 10 times the rated current

MINIATURE CIRCUIT BREAKERS

Miniature circuit breakers for use on motor, space heater control circuits shall comply with the requirements of applicable standards, unless otherwise mentioned in Data Sheet-.

MOTOR PROTECTION CIRCUIT BREAKERS(MPCB)

Motor protection circuit breakers (MPCBs) shall be provided when called for in Data Sheet-/SLD, for use in lieu of switch-fuse for the motor controls. The MPCBs shall conform to the latest applicable standards.

ELECTRONIC OVERLOAD RELAYS

Electronic overload relays shall be provided when called for in Data Sheet-. The relays shall conform to the latest applicable standards.

SOFT STARTERS/AUTO TRANSFORMER STARTERS

Magnetic flux controlled or electronic or auto transformer starters shall be provided when called for in Data Sheet. They shall conform to the latest applicable standards.

EARTHING

An earthing bus shall be provided at the bottom and extended throughout the length of the switchgear. It shall be bolted / welded to the frame work of each unit and each breaker earthing bar. Earth bus-bar shall be extended outside the Panels/DBs at both the ends. The size shall be selected based on the rated symmetrical short circuit rating of the associated switchboard/ panel. The same shall be properly supported to withstand stresses induced by the rated symmetrical short circuit current.

All non-current carrying metal work of the switchgear shall be effectively bonded to the earth bus. Hinged doors and detachable components inside the feeder shall be earthed through individually flexible earthing braid. The earth wire shall be green colour (with yellow band), FRLS PVC insulated, multi stranded copper conductor wire of size 4 sq.mm duly crimped with ring type lugs and to be looped & connected to horizontal earth bus

Positive earthing of the circuit breaker/ disconnecter frame shall be maintained both in service and test position.

INSTRUMENT TRANSFORMERS

The ratings of instrument transformers specified in SLD or A3 are approximate. The BIDDER shall ensure that the specified ratings are adequate for the relays and meters furnished by him. If specified ratings are not adequate the BIDDER shall offer instrument transformers of required rating.

The CTs and VTs shall be cast resin type or nylon encapsulated as specified in Data Sheet with insulation Class B or better and withstand momentary and short time current ratings of the associated switchgear. For feeders with fuse, CTs shall have withstand capacity equal to let-through current of associated fuse.

Unless otherwise specified in SLD or Data Sheet A3 minimum performance requirements of CT's & VTs shall be as follows :

Current Transformers:

- (p) Measuring CTs - 10VA, accuracy Class 0.5 and ISF of 5 Protective CTs - 5 VA , accuracy class of 5P-10
- (q) CTs shall be provided with test links in both secondary leads for carrying out current and phase angle measurement.

Voltage Transformer

- (r) Measuring VT's - 50 VA per phase with accuracy class of 0.5
- (s) Protective VT - 50 VA per phase with accuracy class of 3.0.
- (t) Dual purpose VT - 100 VA per phase and dual accuracy of 1.0/3.0 for metering and protection respectively
- (u) Voltage transformer shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system and 1.9 for 8 hours for non-effectively earthed system.
- (v) Voltage transformers shall be complete with suitable rated protective devices like Fuse / MPCB/ MCB for primary, secondary and tertiary winding. Primary protective device shall have a rupturing capacity equal to the rupturing capacity rating of the associated switchgear. Protective device shall be provided on each sub circuit.
- (w) It shall be possible to replace voltage transformers without having to de-energise the main bus bars.
- (x) The terminals of VT secondary and tertiary windings which are required to be connected to earth shall be earthed by an isolating link without a fuse.

Current transformers shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block

Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear, as indicated in the Technical Specification. CT core laminations shall be of high grade silicon steel. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers

SWITCHGEAR ACCESSORIES AND WIRING

Switchgear shall be supplied completely wired internally up to terminal blocks ready for the PURCHASER's external cable connections at the terminal blocks. Inter panel wiring between cubicles of same switchgear shall be routed inside by the VENDOR.

All auxiliary wiring shall be carried out with 1100 volts grade, single core, multistranded copper conductor with FR PVC insulation.

Following sizes and colour coding shall be used for the Panel wiring :

- (a) Control circuit wiring minimum 1.5 Sq.mm Grey colour wire.
- (b) CT circuit wiring minimum 2.5 Sq.mm Red, Yellow & Blue colour wire.
- (c) PT circuit wiring minimum 1.5 Sq.mm Red, Yellow & Blue colour wire.
- (d) Power circuit wiring minimum 4.0 Sq. mm Red, Yellow & Blue colour for Ph and Black for Neutral wire.
- (e) Earthing wire – Green/ Green with Yellow colour Band

Terminal blocks shall be of stud type, 1100 volts grade, 10 amps. rated complete with insulated barriers. Terminal blocks for CTs and VTs shall be provided with test links and isolating facilities and CT terminals shall have short circuiting and earthing facility. Terminals shall be suitable to take up two numbers of 2.5 sq. mm. copper wires. All terminals of different control voltages shall be separate from each other. Suitable barriers shall be provided between two terminals connected to different voltage supplies

All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks. 20% spare terminals to be provided for each terminal strip for each panel. The terminal blocks shall be located suitably spaced from each other and atleast 200mm from the side/ bottom wall or any adjacent feeder component to provide better convenience for

running the wire troughs and termination of the control cables. All panels shall have Terminal block suitable for connecting minimum 6sq.mm. conductor unless otherwise stated

Accuracy class for indicating instruments shall be as specified in Data Sheet. Instruments shall be 96 mm square 90° scale or 144 mm square taut band type as specified in Data Sheet for semi-flush mounting with only flanges projecting. The instruments shall be analogue or digital type as specified in Data Sheet. All digital meters shall indicate true RMS. Digital Multifunction meter shall display all electrical parameters like (but not limited to) following metering features : Current, Voltage, Frequency, Energy (kWh), MD (kW/kVA), PF, kVAh, kVAR, kVARh, V THD, I THD, etc. For analogue meters dials shall be white with black numbers and lettering

Relays shall be suitable for semi-flush mounting with only flanges projecting.

All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose and shall be included in the VENDOR'S scope of supply. All auxiliary relays and timers shall be supplied in non-draw-out cases. All relays shall be of self reset type except lockout relay unless otherwise specified. Externally operated hand reset flag indicators shall be provided on all relays and timers. Timers shall be of electronic type only. All protective relays shall be electro magnetic type or numerical as specified in Data Sheet

Control and instrument switches shall be rotary type provided with escutcheon plates clearly marked to show operating position and suitable for semi flush mounting with only switch front plate and operating handle projecting out.

Breaker control switches shall be pistol grip black and selector switches shall be oval or knob, black. Breaker control switches shall be 3 position spring return to neutral. Instruments selector switches shall be of the maintained stay-put type. Contacts of the switches shall be spring assisted and contact faces shall be with rivets of pure silver. The contact ratings shall be adequate to meet the requirements of circuit capacity in which they are used. If specified in Data sheet, control switches with built-in flashing type discrepancy lamp shall be provided to control circuit breaker.

Push buttons shall be provided wherever specified. They shall be provided with inscription plates engraved with their functions. Push buttons shall be rated for 10A at 240 AC and 1A at 220 VDC, with 2 NO and 2NC contacts. Start PB shall be green in color and stop PB shall be red colored stay put type.

Indicating lamps shall be Cluster type LEDs.

Space heaters of adequate capacity shall be provided inside each vertical section of the switchboard. They shall be suitable for 240 V, 1 ph, 50 cycles supply. They shall be complete with MCB or HRC fuses as specified in Data Sheet, isolating switches and adjustable thermostat (range 25 to 90 degree centigrade). Heater shall be mounted at bottom of the panel with cover to avoid accidental contact of heater with skin.

Each switchgear panel shall be provided with 240 Volts, 1 phase. 50 cycles, 6 amps. 5 pin receptacles with switch/ MCB located in a convenient position.

The single phasing preventer relay shall be provided when called for in Data sheet- and shall have following characteristics:

- (a) Operate for supply voltage unbalance of more than + 5% and when relay internal wiring is open circuited.
- (b) Not operate for 3 ph supply failure.
- (c) Instantaneous hand reset type
- (d) Visual indication for operation
- (e) Suitable for reversible and non-reversible motors

WINDOW TYPE ALARM ANNUNCIATOR

The alarm annunciator if called for in Data Sheet- shall consist of flush mounted facia and shall have following features:

- (f) Fault indication by steady lit window
- (g) Audible alarm on fault occurrence
- (h) Acknowledgement, resetting and test
- (i) Suitable for NC/NO initiating contacts
- (j) Facility for separate audio-visual alarm on control supply failure

The alarm annunciator scheme operation shall be as follows:

		Visual	Audible
		Alarm	Alarm
		-----	-----
(k)	Normal	OFF	OFF
(l)	On occurrence of fault -		
	(i) First fault	Flashing	ON
	(ii) Subsequent faults	Flashing	ON
(m)	Accept fault -		
	(i) First faults	Steady	OFF
	(ii) Subsequent faults	Steady	OFF
(n)	Reset - Faults cleared	OFF	OFF
(y)	Faults not cleared	Steady	OFF
(z)	Lamp test	Steady	OFF

Panel wiring and cabling shall be cross-ferruled. Each control wire shall be with identification ferrule of Terminal No., component designation and cross ferruling on both sides. Ferrules shall be printed type.

Panel illumination lamp shall be 9 W LED lamp with fixture & door limit switch. It shall be provided inside incomer and each cable alley / compartment.

Separate metering compartment shall be provided for all analogue / digital meters and its accessories like load manager, voltmeter, ammeter, indication lamp, Voltmeter and ammeter selector switch etc. All wiring & MCB / fuses shall be mounted in metering compartment such that meter maintenance is independent of the power compartments.

All power wiring for rating up to and including 63A shall be carried out with 1.1kV grade coloured FR PVC insulated, for phase identification, multi stranded copper wires duly crimped with ring type lugs.

Power connections for rating above 63A shall be done with bus bars (machine bend for proper profile) insulated with black heat shrinkable sleeves with phase identification-coloured tapes duly supported on SMC insulators and placed with required clearance between phases and between phase to ground/ neutral as specified in Data Sheet . Such bus when brought out of the feeder for cable connections shall be sufficient enough and

profiled suitable for termination of the prescribed number of cables as indicated in the SLDs enclosed

ARC RESISTANCE

The switchgear assembly shall be certified as Arc Resistant. The minimum arcing duration used for testing shall be 500ms as specified in the applicable standard.

Rear venting flaps in the panel shall be provided for added air flow under normal operating conditions but automatically close during an arc event to prevent pressure and gases from escaping.

The panel top shall be provided with roof flaps for pressure relief created by an internal arcing event.

CABLE TERMINATION

If asked for in Data Sheet- the necessary number of cable glands and lugs shall be supplied for terminating power and control cables. Glands shall be double compression type, of heavy-duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc. The lugs shall be tinned copper/ aluminum depending on cable conductor and of solder-less crimping type.

LOCAL PUSH BUTTONS/ PB STATIONS

The local P.B. stations shall be metal enclosed, provided with IP-55 protection, made up of die-cast aluminum or 2 mm thick sheet metal.

The P.B. station shall be suitable for wall or structure mounting, provided with labels, earthing terminals, suitable lugs glands.

Push buttons shall be fitted with 2NO and 2NC contacts (1A at 220V DC and 10A at 240V AC) with stop PB of stay put type and red in color. Other PB's shall be green in color.

PB station shall be of one of the following types.

Type A - Three PB's forward-reverse-Stop for reversible motors

Type B - Two PB's start-stop for non-reversible motors

Type C - One PB STOP for emergency

Start push button shall be recess type, spring return. Stop push button shall be stay-put lockable type with Mushroom head.

Start" and "Stop" push buttons shall be coloured green and red respectively.

SPARE PARTS

The BIDDER shall furnish a list of recommended spare parts for five years operation along with unit prices.

TESTS AND REPORTS

Type test reports for the switchgear panel of similar rating for the following tests shall be submitted along with the Bid (not older than 5 years):

- (a) Temperature rise
- (b) Degree of protection
- (c) Internal arc
- (d) Short circuit
- (e) Salt spray test for a minimum duration of 500 hrs (if asked for in Data Sheet)

The switchgear, circuit breakers and all associated equipment shall be tested in accordance with relevant standards. All routine tests shall be carried out. Type tests shall also be carried out if not tested previously.

Type and routine test report shall be submitted for the PURCHASER's approval before the equipment is dispatched. Bound copies of test reports shall be furnished along with the switchgear.

All meters and other reference devices used for testing shall have valid calibration from reputed national / international laboratories / institutes as applicable. Inspection by Purchaser/ Engineer will not be carried out unless the Vendor confirms that calibrated equipment are ready for proceeding with the tests

Equipment shall not be dispatched unless the test certificates are duly approved by the PURCHASER/ ENGINEER.

Vendor shall carry out all routine tests as specified in relevant IS/ IEC standards on all major components and furnish copies of test reports for PURCHASER's approval. Wherever required, Vendor shall conduct the necessary type tests in the presence of PURCHASER's representative based on the unit prices available in the bid.

Vendor shall also carry out all routine and functional tests as specified in the relevant IS/IEC on the assembled switchgear panels in the presence of the PURCHASER's representative at work before despatch and furnish copies of test reports for approval. If required stage inspection, will be carried out by the Purchaser.

VENDOR shall furnish copies of routine test report for all bought out items for PURCHASER's approval.

DRAWINGS AND DATA

The following shall be furnished as part of the tender:

General arrangement showing plan, elevation and typical sectional views.

Technical literature on the equipment offered.

Quality Assurance Plan.

MAINTENANCE REQUIREMENTS

Easy access shall be provided for all components in the switchgear for maintenance.

As far as possible the switchgear shall be so designed that no special tools are necessary for installation and maintenance. However, if special tools are required, the Bidder shall include price of one complete set in his bid.

The Bidder shall include supply of Essential spares specified in Data sheet- and also Recommended Spares for three (3) years trouble free operation, in Section-F.

Vendor shall furnish detailed inter panel wiring diagrams, internal wiring diagrams, detailed component layout drawings to enable the purchaser to carry out maintenance work.

DATA TO BE FURNISHED BY THE VENDOR AFTER AWARD OF THE CONTRACT

LIST OF DRAWINGS

The VENDOR shall furnish the following drawings for each panel after placing the order. If a large number of switchgears are involved, the PURCHASER will indicate the priorities.

Overall outline dimensions and general arrangement including plan, front elevation, rear & side elevations, clearances required in front and back, details of bus duct connections, if any.

Switchgear layout plan including floor openings, fixing arrangements and loading details.

Schematic control diagrams to cover controls, protection, interlocks, instruments, space heaters, etc. for each type of module

Detailed internal wiring diagram of each type of module, including terminal block numbers, ferrule numbers and the PURCHASER's external cable connection designations

Itemised bill of material for each switchboard

Interpanel interconnection wiring diagram including terminal numbers and ferrule numbers

Switch development diagrams

Each type of protection relay and circuit breaker release characteristics

Fuse characteristic curves for each type and rating of fuse

(a) The VENDOR shall be entirely responsible for the correctness of the internal wiring diagrams

TEST CERTIFICATES

Type test certificates of all standard component parts, e.g. contactors, breakers, switches, fuses, relays, CTs, VTs, and for the standard factory built assembly shall be submitted by the VENDOR within 3 months from receipt of order.

INSTRUCTION MANUALS

The VENDOR shall furnish specified number of copies of the instruction manual which would contain detailed instructions for all operational and maintenance requirement. The manual shall be furnished at the time of despatch of the equipment and shall include the following aspects :

All final approved scheme drawings and single line diagrams shall be submitted in latest version of AUTOCAD and the same shall be submitted in CD's

(a) Outline dimension drawings showing relevant cross-sectional views, earthing details and constructional features.

(b) Rated voltages, current, duty-cycle and all other technical information which may be necessary for correct operation of the switchgear.

(c) Catalogue numbers of all components liable to be replaced during the life of the switchgear.

(d) Storage for prolonged duration.

(e) Unpacking.

(f) Handling at site.

(g) Erection.

(h) Pre-commissioning tests.

(i) Operating procedures.

(j) Maintenance procedures.

(k) Precautions to be taken during operation and maintenance work.

1.	LOW VOLTAGE POWER FACTOR CORRECTION	☐ IS: 61921	☐ BS:	☐ IEC
2.	AC CIRCUIT BREAKERS	☐ IS 60947-2	☐ BS:3871(PI)	☐ IEC 60947-2

3.	LOW VOLTAGE SWITCHGEAR AND CONTROL GEAR	☐ IS:61439 IEC:61439	☐ BS:5486	☐
4.	AIR BREAK SWITCHES	☐ IS:60947-3 IEC-60947-3	☐ BSEN:60947-3	☐
5.	CURRENT TRANSFORMERS	☐ IS:2705 IEC:60044	☐ BS:7626	☐
6.	VOLTAGE TRANSFORMERS	☐ IS:3156 IEC:60044	☐ BS:7625	☐
7.	DEGREE OF PROTECTION	☐ IS:60947(PI) IEC:60947-1	☐ BS:	☐
8.	CODE OF PRACTICE FOR INSTALLATION AND MAINTENANCE OF SWITCHGEAR	☐ IS:10118	☐ BS:	☐ IEC:
9.	CODE OF PRACTICE FOR PHOSPHATING IRON AND STEEL	☐ IS: 6005	☐ BS: 3169	☐ IEC:
10.	GUIDE FOR TESTING UNDER CONDITIONS OF ARCING DUE TO INTERNAL FAULT	☐ IS: 61641	☐ BS:	☐ IEC
11.	TESTING GUIDE	☐ ANSI/IEEE C.37.20.7		
	EQUIPMENT, ACCESSORIES, COMPONENT PARTS, RAW MATERIALS AND TESTS SHALL BE IN GENERAL CONFORM TO ☐ BS ☐ IEC: ☐ IS:			

5. **APFCR PANELS**

This specification covers the design, material, principle of operation, manufacture, inspection and testing at the Vendor's works, delivery to site and performance testing of capacitor controller for automatic switching of capacitor banks sequentially as required to give a desired power factor.

The relay shall be numerical type giving signal to contactors/ TSC (thyristor switched capacitors) for switching on/off preset number of capacitor units.

The relay shall have sufficient output contacts to switch on required number of capacitors as required.

CODES & STANDARDS

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be the latest as on the day of execution of the works unless otherwise specified. The revisions in the relevant codes and standards after the date of award of contract shall be informed by the Contractor to the Consultant/ Owner within 30 days of the issue of such revision of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

BASIC REQUIREMENTS

It would be a digital electronic device for the automatic/manual control of power factor correction capacitors on three phase system. It shall detect the power factor lagging and

Bidder's Stamp & Initials

leading reactive power (kVAR) component above preset levels, and then switch the appropriate number of capacitors 'IN' or 'OUT' to achieve the optimum average power factor without system operating under leading power factor condition.

The digital relay would have low VA burden and final switching of appropriate capacitor banks would be achieved by switching on/off of Contactors/TSC, through initiation of this device.

PRINCIPLE OF OPERATION

On deviations from set power factor, the controller shall release command signals to switch on/switch off capacitor bank stages and maintain the set power factor. The dead band shall be provided in the inductive and capacitive region of the set power to avoid frequent switching operations. The dead band limit shall be adjustable depending upon the switching steps.

The device shall have various programming steps to set different switching combinations to take care of varying load conditions.

STANDARD FEATURES

- (a) To measure/monitor power factor and VAr continuously. Status of switching step shall be displayed through LED.
- (b) Following adjustment shall be provided.
 - Power factor
 - Dead band capacitive region with respect to set power factor (pf).
 - Inductive region with respect to set pf
 - Operating time for programmable switching steps.
 - Auto/manual selector switch.
 - Manual step control.
- (c) All control knobs, LEDs for display and selector switches shall be mounted on the front face of relay casing/panel.
- (d) It shall be fully programmable.
- (e) There shall be a choice for customer to select operating sequence upto 4 to 5 which will have maximum number of steps of capacitors equal to sixteen (16 Nos). The sequence shall be arithmetic 1,2,3....6,7,8.
- (f) Operating time selection of time interval designation between switching stages shall be possible using time selector switches. The device shall take care that any stage which has just been switched out, will only be reconnected by the pulse counter, after 60 secs. has elapsed so that it has safely discharged. This is a requirement for 415V capacitors; for 11kV or 6.6 kV capacitors the time interval for any stage to be switched again shall be 10 minutes (corresponding to the safe discharge time for 11kV or 6.6 kV capacitors).
- (g) Loss of voltage element. This would prevent abnormal switching surges on loss of supply. Also, it would control the switching on/off surges.
- (h) Dead band features – Relay response sensitivity adjustable using dead band so that hunting is prevented.

Auto/Manual control – This would help testing and commissioning at site as well as ease in operation when either mode fails during service time.

DATA TO BE FURNISHED BY THE VENDOR AFTER THE AWARD OF CONTRACT

Sl.No.	DOCUMENTS	PURPOSE
1.0	Instruction manuals	For Information
2.0	Test Reports	- do -
3.0	Schematic diagram for PF control	- do -
4.0	Essential spares	- do -
5.0	General Arrangement drawing of controller panel showing main dimensions, type of mounting, weight etc.	For Further Engineering

SL. NO.	BRIEF NAME	REFERENCE STANDARDS		
1.0	APPLICABLE STANDARDS			
1.1	Electrical relays for power system protection	☐ IS-3231	☐ BS	☐ IEC-60255
1.2	Environmental tests for electronic & elec. equipment	☐ IS-9000	☐ BS	☐ IEC 60068-2
1.3	Shunt capacitors for power systems	☐ IS 13585 & 13925	☐ BS	☐ IEC-60871 & 60931

ACTIVE HARMONIC FILTER

This specification defines the requirements for active harmonic filter systems in order to fulfill the requirements of IEEE-519-1992 or IEEE-519-2014 for the harmonic current limits. By reducing harmonic current in the network, the active harmonic filter will increase the lifetime of the electrical equipment and increase the customer's electrical energy efficiency.

- General Requirement -
- The active harmonic filter shall be provided by reputable supplier who can demonstrate adequate experience in the power quality and active harmonic filtering sector.
- The supplier's manufacturing process shall be audited in accordance with ISO 9001 quality standard.
- The active harmonic filter shall be connected in parallel with the load to be compensated.
- The active harmonic filter shall be compatible with any supply voltage from 200 V up to 480 V.
- The active harmonic filter shall be compatible with both 50Hz and 60Hz networks.
- The nominal output current of the active harmonic filter modules shall be as per SLD/BOQ. It should be expandable to any range by means of paralleling.
- The configuration of the active harmonic filter shall be selectable to either 3- wire or 4-wire connection in order to filter harmonics from phase conductors and optionally the neutral conductor.
- The active harmonic filter shall not need any external controller other than those built into the unit.

- The active harmonic filter shall measure all three phases of line current in real time and generate the measured harmonics currents in opposite phase by means of a Digital Signal Processor (DSP) based system.
- The active harmonic filter power inverter module shall be neutral point clamped 2-level topology based IGBT technology to provide good and accurate output current. The PWM modulation technology using fixed switching frequency shall be used. The switching frequency shall not be less than 20kHz to minimize audible noise.
- The active harmonic filter shall be capable of measuring the network currents from either the supply side or the load side allowing closed loop or open loop current control.
- The current signal provided by split core current transformers of Class 0.5 accuracy shall be sufficient for proper filter operation and performance.
- There shall be galvanic isolation between the current measuring transformer signals and active harmonic filter control electronics input.
- Ability to cancel all odd harmonics up to 51st order. These harmonics are individually selectable and programmable with on limitation.
- Control method using the FFT (Ultra-fast computation) using digital controller
- The active harmonic filter shall have an operation mode enabling the user to set a target percentage of wanted mitigation of harmonic components
- The active harmonic filter shall be capable of providing fundamental frequency reactive power compensation up to full nominal output. This reactive power can be either capacitive or inductive.
- The active harmonic filter shall be capable of load balancing up to full nominal output current.
- The active harmonic filter shall have an automatic re-start feature enabling recovery of normal operation after a black out of the supply system or after being subjected to a non-severe condition.
- The active filter shall recognize the main voltage rotation and give indication if this is not correct
- The active harmonic filter shall have speed-controlled fans which are controlled via temperature in order to increase component lifetime and decrease heat losses.

Control Circuit

- a. Control MCB of rating 10A-FP-10kA-C Curve to provide power supply to the control circuit of the active filter
- b. Advanced DSP microprocessor controller which shall monitor the voltage and current in the three phases (Red, Yellow and Blue) to compute the exact power requirement in the three phases, and thus, implement the following features - step-less compensation of leading and lagging power factor, harmonics compensation and load balancing
- c. Suitable number and rating of voltage and current sensing circuits
- d. Necessary control and firing cards with proper wiring and lugs of required rating shall be provided
- e. Suitable number and rating of any other items, e.g. relays, SMPS, etc.
6. The APFC panel shall have the following features, in addition to those already mentioned above:
 - i. Panel shall be suitable for operation within an ambient temperature between 0 deg C and 45deg C
 - ii. Panel shall have an audible noise level lesser than 70db
 - iii. Panel shall have a filtering efficiency of at least 97%
 - iv. Panel shall have a reaction/response time of at least 200 micro-seconds
 - v. Power factor correction shall always be set at first priority Target PF level shall be programmable at the time of commissioning
 - vi. Priority selection between the remainder features - harmonics compensation and load balancing - shall be programmable at the time of commissioning In the default mode, harmonics compensation is set at 2nd priority and load balancing is set at 3rd priority

- vii. Auto fold-back of the HPFC panel if total current requirement exceeds the rated capacity of the panel
- viii. Bus-bars or cables shall be suitably color coded and mounted using appropriate insulator supports Suitable clearances shall be provided for the bus-bars and other live parts of the system as per international standards
- ix. All live parts of the system shall be properly shrouded
- x. Inspection terminal strip, number ferruling, and other labeling shall be suitably provided
- xi. Stickers marked with “DANGER” shall be provided wherever required
- xii. Detailed drawings and manuals shall be provided wherever required
- xiii. Following protections shall be provided:
 - a. Over voltage (AC) protection
 - b. Over voltage (DC) protection
 - c. Phase sequence protection
 - d. Over current protection
 - e. Over temperature protection
 - f. Protection circuits for the inverter stack and its components
- xiv. All components and wiring used in the system shall adhere to the relevant ISI and IEC standards

6. CABLES

This specification covers the requirements of Power Cables up to 33kV, Control, Instrumentation (up to 400 degrees centigrade), Communication and Lighting Cables with general purpose insulation and sheaths. Requirement of special outer sheaths with Heat Resistant (HR), Fire Survival (FS) and Flame Retardant Low Smoke (FRLS) characteristics are also covered in this specification.

CODES AND STANDARDS

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

GENERAL CONSTRUCTIONAL FEATURES

The following aspects are applicable for all types of cables covered in this specification.

Conductor

- (a) Aluminium conductor, circular, compacted stranded, grade H4, Class 2 as per IS mentioned in data sheet for power cables. 'Ó' grade aluminium shall be used for solid conductor of the welding cable conductor.
- (b) Annealed, stranded Copper Conductor, Class 2 as per relevant IS for control cables. For flexible cable, class shall be 5 or 6 and for CU welding cable, class shall be 6.

Conductor Screen

All cables rated above 3.3/3.3 kV shall be provided with conductor screening. Conductor screening shall be provided over the conductor by applying non-metallic semi-conducting tape or by extrusion of semiconducting compound or a combination of the two.

Insulation

Insulation for cables shall be XLPE for HV power cable (above 1100V grade) and PVC/ XLPE for LV power (1100V grade), control / lighting / instrumentation and communication cable applied by extrusion.

Core Identification

Colour coding shall be acceptable for all cables up to 5 cores. Cables with more than 5 cores shall have printed numerals every 50mm on each core.

Inner Sheath

Inner sheath when specified shall be extruded type PVC and shall be compatible with the insulation provided for the cables as per IS mentioned in data sheet.

Armour

Armouring for the cables shall comprise galvanised steel or hard drawn aluminium, in the form of round wires or strips following IS mentioned in data sheet.

W	-	Galvanised round steel wire
F	-	Galvanised flat steel strip
AW	-	Hard drawn single aluminium wire.
AS	-	Hard drawn single aluminium strip

Insulation Screening

(a) All cables rated above 3.3/3.3 kV shall be provided with insulation screening. The screening shall consist of one or more of the following, as Specified.

(i) Non-metallic part – it shall be applied over the insulation of each core and shall consist of either semiconducting tape or extruded semi conducting compound or a combination of the two.

(ii) Metallic part – it shall consist of either tape, or braid, or concentric serving of wires or a sheath. It shall be non-magnetic and shall be applied over the non-metallic part.

NOTE-The semi-conducting tape and semi-conducting compound shall be suitable for the operating temperature of the cable and compatible with the insulating material.

Outer Sheath

The outer sheath shall be of an extruded layer of PVC (poly vinyl chloride) compound with the specified ambient and operating temperature of the cables. The sheath shall be heat resistant, resistant to water, ultraviolet radiation, fungus, termite and rodent attacks. The colour of the outer sheath shall be black. PVC sheath shall meet the requirements of standards covered under 3.1.5 above. Requirement of special sheath with Fire Survival (FS) and Flame Retardant Low Smoke (FRLS) characteristics shall be as per clause 5.0. Requirement of Fire Protective Paint on outer sheath of the cable shall be as per Data Sheet.

Cable Drums

Cables shall be supplied in non-returnable wooden or steel drums as applicable. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage. Cable drums shall conform to standard mentioned in datasheet.

The BIDDER shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of +5 % with an overall ceiling of +5% on total ordered quantity of each size of cable. Negative tolerance is not acceptable. However, before winding the cables on drums, VENDOR shall obtain PURCHASER's approval for the drum lengths so as to minimise the number of joints to the extent possible. Cable ends shall be sealed by non-hygroscopic sealing caps.

Cable drums shall carry following details in printed form:

IS code.

- (a) Manufacturer's name and trademark
- (b) Type of cable and voltage grade
- (c) Year of manufacture
- (d) Type of insulation
- (e) No. of cores and size of cables
- (f) Cable code
- (g) Length of cable on drum
- (h) Inner Diameter and Outer Diameter of Drum

Cable lengths specified in Data Sheet are approximate only. Actual requirements will be advised to the successful BIDDER at the time of placing the order. Incremental cable lengths in meters shall be embossed on the outer sheath of every 1 metre interval.

Cable drum length shall be intimated to the successful BIDDER two (2) months prior to start of manufacturing date.

DATA TO BE FURNISHED

DATA SHEET

BIDDER shall furnish the information called for in Data Sheet for each type of cables. All BIDs shall be accompanied by descriptive technical catalogues.

REQUIREMENT OF SPECIAL SHEATH FOR FRLS/FS CABLE

When specified in Data Sheet, outer sheath for FRLS/FS cables shall meet the following test requirements related to flame retardance, low smoke emission, low acid and toxic gas emission. The BIDDERS shall have proper test apparatus to conduct all the relevant tests as per the applicable Standards mentioned herein.

Tests for Flame Retardance

- a. Oxygen Index

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The critical oxygen index value shall be minimum 29 when tested at $27 \pm 2^\circ\text{C}$ as per relevant standard mentioned in data sheet and the temperature index value shall be minimum 250°C at oxygen index of 21 when tested as per relevant standard as mentioned in data sheet.

b. Flammability

- (i) Cables shall pass test under fire conditions as per relevant IS standard.
- (ii) Cables shall also pass tests as per relevant IS standard.
- (iii) Fire survival cables in addition to tests (i) and (ii) above shall pass tests as per relevant IEC.
- (iv) Cables shall pass test as per relevant IEC, IEEE, and Swedish chimney test F3 as per SS 424-1475.

Tests for Smoke Generation

The cables shall satisfy the tests conducted to evaluate the percentage obscuration by smoke in an optical system placed in the path of the smoke. The maximum smoke density rating shall not be more than 60% when tested as per standard mentioned in data sheet.

Tests for Acid Gas Generation

The hydrochloric acid generation when tested as per relevant IEC mentioned in datasheet. shall be less than 20% by weight.

Tests for Resistance to Ultraviolet Radiation

This test shall be carried out as per relevant standard. The retention values of tensile strength and ultimate elongation after the tests shall be minimum 60% of tensile strength and ultimate elongation before test.

Tests for Water Absorption

Outer sheathes shall be subjected to tests for water absorption as per IS mentioned in datasheet. When additional characteristics are required, the tests shall be as agreed between PURCHASER and VENDOR before the placement of order.

Anti-rodent and termite repulsion test

SPECIFIC REQUIREMENTS

The various types of cables covered in this specification shall meet the following requirements:

1100V Grade Power Cables

The cables shall be insulated with extruded PVC/ XLPE compound provided with extruded PVC inner sheath, armoured/ unarmoured and outer sheath of extruded black PVC compound as per data sheet.

The construction, performance and testing of the cable shall comply with relevant IS.

1100 V Grade Control Cables

The cables shall be insulated with extruded PVC/ XLPE compound, provided with extruded PVC inner sheath and outer sheath of extruded black PVC compound as per data sheet.

The construction, performance and testing of the cable shall comply with the standards mentioned in data sheet.

XLPE Insulated HV Power Cables

The conductors shall be screened by extruded semi-conducting compound and XLPE insulated applied by extrusion. The cores shall be screened by extruded semi-conducting compound in combination with non-magnetic metallic tape (copper tape preferred). PVC inner sheath over laid up cores shall be extruded and outer sheath over the armour shall be extruded black PVC compound type ST-2. Core identification shall be by printed numerals.

The construction, performance and testing of the cable shall comply with relevant IS.

Telecommunication Cables

The cables shall meet the following requirements:

- (a) Conductor: Solid, tinned, annealed copper
- (b) Insulation: PVC insulation type-A as per relevant IS

- (c) Twisting: The insulated conductors shall be twisted together to form twisted pairs or quads; these shall be stranded in concentric layers to form the cable core. The cable thus formed shall be tightly lapped with outer wrapping tapes.

The interstices of insulated cable core shall be completely filled with viscose compound.

- (d) Overall: With 0.075 mm aluminium tape or 0.013 mm melinex screening tape, overlap not less than 30%.
- (e) Other details: A suitable non-magnetic rip cord shall be laid details longitudinally under the sheath. The armouring shall be of galvanised steel wires or galvanised single steel strip. The inner PVC sheath shall be of type-A. The outer PVC sheath shall be of Type ST-1.
- (f) Voltage tests for: Dielectric withstand between conductors - 500V for 1 minute (rms) and between conductor & sheath -2000V rms/3000 V DC.

450/750 V Grade Light duty unarmoured cables

Cables shall be insulated with extruded PVC type-A. Outer sheath shall be extruded black PVC type as indicated in data sheet. The sheathed cables shall be weatherproof suitable for indoor/outdoor use. Twin and multicore cables shall be laid up and filled with thermoplastic material, bound by plastic tape and provided with outer sheath. Aluminium conductor, circular, compacted stranded, grade H4, Class 2. For copper conductor, conductor shall be annealed, stranded, Class 2 as per relevant IS. For flexible cable, copper conductor class shall be 5 or 6 and for CU welding cable, class shall be 6.

Instrumentation Cables

Cables shall comply with the following requirements:

Conductor : Annealed, tinned copper in solid or stranded circular construction

Insulation : PVC type-A applied by extrusion process.

The insulation shall be strippable manually as well as by mechanical stripping devices without damage to the conductor.

Element identification : As per relevant IEC

Core wrapping : By non-hygroscopic material by taping or by extrusion.

Element screening : By copper tape of minimum 0.04 mm thickness or by copper laminated plastic tape when specified in Data Sheet.

Rip cord : Non-metallic rip cord under the core wrapping

Drain wire : A tinned copper drain wire of minimum 0.5mm² cross section in contact with each screen of cabling element.

Cabling elements shall be any one of the following :

A 'Pair' of two insulated conductors twisted together designated by alphabet 'p' printed on a binding tape at 200 mm intervals.

A 'Triad' of three insulated conductors twisted together designated by alphabet 't', printed on a binding tape at 200 mm intervals.

A 'Quad' of four insulated conductors twisted together and designated by alphabet 'q' printed on a binding tape at 200 mm intervals.

A 'Quintuple' of five insulated conductors twisted together or by combination of one quad & one untwisted wire or 2 pairs and one untwisted wire. The quintuple shall be designated by alphabet 'Q' printed on a binding tape at 200 mm interval.

Maximum length of lay in the finished cable shall be 120 mm.

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Units

Cables shall be bunched together in units of twenty cabling elements or sub units of five or ten elements, stranded in concentric layers. The units or sub units shall be designated by p1, p2, p3,..., t1, t2, t3..., q1, q2, q3, ..., or Q1, Q2, Q3 ..., etc. depending on the combination.

Overall screening and armouring

Cables shall have an overall screen made up of copper/aluminium tape of 0.04 mm thickness or copper/aluminium of 0.008 mm thickness laminated with plastic tape with a minimum overlap of 15%. A drain wire of tinned copper with minimum 0.5 mm² cross section shall be provided in continuous contact with the screen. Armouring when specified shall be of galvanised steel strips.

Inner and Outer Sheath

The inner and outer sheaths shall consist of black PVC compound Type ST-1.

Voltage grade - Dielectric between conductors shall withstand for 1 minute the following voltages:

- a) Conductor diameter up to 0.6 mm - 1000 V AC or 1500 V DC
- b) Conductor diameter above 0.6 mm- 1500 V AC or 2250 V DC

Insulation Resistance

Minimum insulation resistance per km shall be 500 mega Ohm.

Mutual Capacitance

Mutual capacitance of any pair of conductors shall not exceed 120nF/km.

Capacitance Unbalance

The capacitance unbalance between any two pairs shall not exceed 400 pF for 500 metre length of cable.

The construction, performance and testing of cables except as modified above shall generally comply with the relevant standards mentioned in data sheet.

Instrument cable for operating temperature up to 400 deg centigrade.

Conductor	: Annealed, bare copper
Conductor Type	: Flexible
Insulation	: Kepton Tape + Sintered PTFE
Overall Shielding	: AL- Myler tape
Drain wire	: Annealed tinned copper drain wire of minimum 0.5mm ² cross section in contact with each screen of cabling element.
Inner Sheath	: Wrapped & sintered PTFE tape
Outer Sheath	: FG tape (Natural) + FG braiding with varnish (natural)
Overall braided Armour material after outer sheath: Stainless steel wire	

Tests and Test Equipment

Cables shall be subjected to routine and acceptance tests in accordance with standards specified. Test methods shall conform to relevant IS. Bidder shall furnish all test certificates for Purchaser's approval. BIDDER shall ensure use of calibrated test equipment having valid calibration test certificates from standard laboratory traceable to National/ International Standards

Construction details including type of material used and thickness of each material for each type of cable in a tabular form and cross section drawings.

Technical catalogues and manuals

Installation and termination instructions.

Test Certificates

Type/Routine test certificates for all types of cables included in the order and special tests on FRLS/FS/ FRLSZH cables in line with applicable standard.

Technical particulars of all cables

QAP for all cables

ITEM	APPLICABLE STANDARDS
Type of conductor	IS 8130 IEC 60228
Conductor Screening	IS 7098 IEC 60502
Insulation	IS 5831 IS 7098 IEC 60502
Armoring	IS 3975
Test and test equipment	IS 10810
Oxygen Index test	ASTM-D-2863
Temperature index value	ASTM-D-2863 / NES 715
Cable drums	IS 10418
Flammability	IS 10810 IEC 60331 IEC 60332 IEEE 383 SS 424-1475
Test for smoke generation	ASTM-D-2843
Test for acid gas generation	IEC 60754-1
Tests for Resistance to Ultraviolet Radiation	DIN 53387
Telecommunication cable, Low frequency cables and wires with PVC insulation and sheath - General Tests and measuring methods	IS 5831 IEC 60189-1 IEC 60189-2
Instrumentation cable	IEC 60189-1 IEC 60189-2
Construction, performance and testing of XLPE Insulated HV Power Cables	IS 7098 IEC 60502
Construction, performance and testing of 1100 V Grade PVC Insulated Power and Control Cables	IS 1554 IEC 60502
Construction, performance and testing of 1100 V Grade light duty unarmoured cables	IS 694
Instrument cable for operating temperature up to 400 deg centigrade	JSS 51034
NOTES	
Equipment, Accessories, Components /Parts Raw materials and tests shall in general conform to:	
	IS BS IEC CBIP

HT Termination Kit

This specification lays down the performance requirements of following types of cable terminations and cable joints for use on electrical system operating at voltages from 3.3kV to 33kV in indoor and outdoor application.

Heat shrinkable type cable terminations and cable joints.

CODES AND STANDARDS

The design, manufacture, testing and performance of HV cable terminations and joints shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied. Nothing in this specification shall be construed to relieve the VENDOR of his responsibility. In case of conflict between these standards and this specification, more stringent of the two requirements shall govern. Some of the currently applicable standards are indicated in Data Sheet

All codes and standards referred to in the specification shall be understood to be the latest version on the date of offer made by the BIDDER unless otherwise indicated.

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The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

HEAT SHRINKABLE TYPE SYSTEM

The term shrinkable refers to extruded or moulded polymeric material which are cross linked to develop elastic memory and supplied in an expanded or otherwise deformed size and shape. Subsequent heating in an unconstrained state to a temperature above the shrink temperature results in the material recovering or shrinking to its original shape.

Stress control and stress grading wherever necessary in the terminations and joints shall be by means of semi-conducting heat shrinkable tubing.

Environmental sealing between the heat shrinkable materials and cable surfaces shall be achieved by using hot melted sealant or adhesives. Where such sealant or adhesives are exposed to high electrical stress, they must be track resistant.

PERFORMANCE REQUIREMENTS

External creepage distance between the high voltage conductors and ground shall be accomplished by utilising heat shrinkable terminations and joints and shall be accomplished by utilising EPDM rubber material for "PUSH-ON" type terminations and joints. These shall be weather resistant.

The termination systems shall have been type tested for the tests listed in the relevant IS / IEC and the type and routine test certificates shall be submitted before dispatch.

AFTER PLACEMENT OF ORDER, THE VENDOR SHALL SUBMIT:

Editable soft copies of final drawings for all the equipment ordered in latest version of Autocad.

Six copies of instruction booklets on laying, jointing and testing of the cables and accessories.

Six copies of descriptive manuals and principal technical data of all equipment ordered.

Six copies of complete test reports.

Guaranteed technical particulars.

<u>APPLICABLE STANDARDS</u>	
Power Cables with extruded insulation & their accessories for rated voltage from 1kV up to 30kV	☐ IS ☐ BS ☐ IEC 60502
Artificial pollution tests on high voltage insulators to be used on A.C systems for salt-fog test	☐ IS ☐ BS ☐ IEC 60507 SEC-3
High voltage test techniques	☐ IS ☐ BS ☐ IEC 60060-1
Joints and termination of polymeric cables for working voltages from 6.6kV up to and including 33kV performance requirements and type tests	☐ IS 13573 ☐ BS ☐ IEC
(Partial discharge measurements) for partial discharge tests	☐ IS ☐ BS ☐ IEC 60270
Cross linked polyethylene insulated PVC specified cables (For working voltage from 3.3kV up to and including 33 kV)	☐ IS 7098 ☐ BS ☐ IEC
Specification for PVC insulated (Heavy duty) electric cable for working voltage from 3.3kV up to and including 11kV	☐ IS 1554 ☐ BS ☐ IEC
NOTES :	
Equipment, accessories, components / parts, raw materials and tests shall in general conform to	☐ IS ☐ BS ☐ IEC

7. CABLE CARRIER SYSTEM

This specification covers the requirements of Cable containments / cable trays for cable installation for efficient and trouble-free operation. Cable Trays shall be hot dip Galvanized and factory fabricated out of G.I. channels, angle iron, tee, bends, sections, flats and perforated sheet for different loads.

CODES AND STANDARDS

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations, and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

LAYING OF CABLE ON CABLE TRAYS

The relative position of the cables laid on the cable tray shall be preserved and the cables shall not cross each other. At all changes in direction in horizontal and vertical planes, the cable shall be bent smooth with a radius as recommended by the manufacturers. All cables shall be laid with minimum one diameter gap and shall be clamped at every meter to the cable tray. Cables shall be tagged for identification with aluminium tag and clamped properly at every 20M. Tags shall be provided at both ends and all changes in directions both sides of wall and floor crossings. All cable shall be identified by embossing on the tag the size of the cable, place of origin and termination.

All cables passing through holes in floor or walls shall be sealed with fire retardant Sealant and shall be painted with fire retardant paint up to one meter on all joints, terminations and both sides of the wall crossings.

LAYING OF CABLE IN GROUND

The width of trench for laying single cable shall be minimum 350 mm. Where more than one cable is to be laid in horizontal formation, the width of the trench shall be worked out by providing 200 mm gap between the cables, except where otherwise specified. There shall be clearance of 150 mm between the end cable and the side wall of the trench. The minimum depth of the cable trench shall not be less than 750 mm for single layer of cables.

When the cables are laid in more than one tier the depth of the trench shall be increased by 300 mm for each additional tier.

Excavation of trenches: The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature shall be provided. Where gradients and changes in depth are unavoidable, these shall be gradual.

The excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench. The bottom of the trench shall be levelled and shall be made free from stone, brick bats etc. The trench shall then be provided with a layer of clean, dry sand cushion of not less than 100 mm in depth. Prior to laying of cables, the cores shall be tested for continuity and insulation resistance. The cable drum shall be properly mounted on jacks, at a suitable location, making sure that the spindle, jack etc. are strong enough to carry the weight of the drum and the spindle is horizontal. Cable shall be pulled over rollers in the trench steadily and uniformly without jerks and strains.

The entire drum length shall be laid in one stretch.

However, where this is not possible the remainder of the cable shall be removed by 'Flaking' i.e. by making one long loop in the reverse direction. After the cable has been uncoiled and laid into the trench over the rollers, the cable shall be lifted off the rollers beginning from one end by helpers standing about 10 meters apart and laid in a reasonably straight line. Cable laid in trenches in a single tier formation shall have a cover of clean, dry sand of not less than 150 mm. above the base cushion of sand before the protective cover is laid.

In the case of vertical multi-tier formation after the first cable has been laid, a sand cushion of 300 mm shall be provided over the initial bed before the second tier is laid. Finally the cables shall be protected by second class bricks before back filling the trench. The buried depth of uppermost layer of cable shall not be less than 750mm.

Back Filling: The trenches shall be back filled with excavated earth free from stones or other sharp-edged debris and shall be rammed and watered, if necessary, in successive layers not exceeding 300 mm. Unless otherwise specified, a crown of earth not less than 50 mm in the centre and tapering towards the sides of the trench shall be left to allow for subsidence.

CABLES INSIDE THE BUILDING

Cables inside buildings shall be laid on the cable trays. All cables passing through walls shall run through GI Pipes sleeves of adequate diameter 50 mm apart maintaining the relative position over the entire length. All Cables running inside building shall be unarmoured cables and cables outside building shall be armoured cables.

ROUTE MARKER

Route marker shall be provided along straight runs of the cables not exceeding 30 meters also for change in the direction of the cable route and underground joints.

Route marker shall be of cast iron painted with aluminium paint. The size of marker shall be 100 mm dia with "Cable" and voltage grade inscribed on it.

CABLE TRAYS

Cable trays shall be of Mild Steel painted/ Galvanised/ Fibre Reinforced Plastic and of ladder / perforated / solid type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings. For Indoor application trays shall be painted/galvanised and for outdoor application it shall be galvanised. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be factory fabricated out of CRCA sheet with standard accessories like tee, bends, couplers etc. for different loads and number and size of cables as given below :

Cable trays shall be galvanized as per Specification given under sss

- 1500 mm wide
 - Runners 25 x 100 x 25 x 3 mm
 - Rungs 2# 20 x 40 x 20 x 3 mm 250 mm C/C
 - Suspenders 2 Nos. 40 x 40 x 5 mm GI angle 1500 mm C/C with base support of 40x40 x 5mm GI angle.
- 1200 mm wide
 - Runners 25 x 100 x 25 x 3 mm
 - Rungs 2# 20 x 40 x 20 x 3 mm 250 mm C/C
 - Suspenders 2 Nos. 40 x 40 x 5 mm GI angle 1500 mm C/C with base support of 40x40 x 5mm GI angle.
- 1000 mm wide
 - Runners 25 x 100 x 25 x 3 mm
 - Rungs 2# 20 x 40 x 20 x 3 mm 250 mm C/C
 - Suspenders 2 Nos. 40 x 40 x 5 mm GI angle 1500 mm C/C with base support of 40x40 x 5mm GI angle.

- 750 mm wide
 - Runners 20 x 75 x 20 x 2.5 mm
 - Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C
 - Suspenders 2 Nos. 32 x 32 x 5 mm GI angle 1800 mm C/C with base support of 40x40 x 5mm GI angle.
- 600 mm wide
 - Runners 20 x 75 x 20 x 2.5 mm
 - Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C
 - Suspenders 2 Nos. 32 x 32 x 5 mm GI angle 1800 mm C/C with base support of 40x40 x 5mm GI angle.
- 450 mm wide
 - Runners 20 x 75 x 20 x 2.5 mm
 - Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C
 - Suspenders 2 Nos. 12/16mm threaded Rod with Slotted GI Angles

Note: Suitable length of 10 mm dia GI rod suspenders at 1800 mm interval shall be included in the item for perforated type cable tray.

Alternative to fabricated support of cable tray, Steel wire rope hangers shall be used to suspend the cable trays. This hanger shall consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings. The end fixings and wire must be of the same manufacturer with several options available. The system shall be secured and tensioned with a hanger self-locking grip at the other end. Once the grip is locked for safety purpose, unlocking shall only be done by using a separate setting key and shall not be an integral part of the self-locking grip. Only wires and/or supports supplied and/or approved shall be used with the system.

SPECIFICATION OF HOT DIP GALVANIZING PROCESS

(for Mild Steel Used For Earthing, Cable Trays Or Junction Boxes For Electrical Installation.)

General Requirements

I. Quality of Zinc

Zinc to be used shall conform to minimum Zn 98 grade as per requirement of IS: 209-1992.

II. Coating Requirement

Minimum weight of zinc coating for mild steel flats with thickness upto 6 mm in accordance with IS:6745-1972 shall be 400 g/sqm.

The weight of coating expressed in grams per square metre shall be calculated by dividing the total weight of Zinc by total area (both sides) of the coated surface. The Zinc coating shall be uniform, smooth and free from imperfections as flux, ash and dross inclusions, bare patches black spots, pimples, lumpiness, runs, rust stains bulky white deposits, blisters. Mild steel flats / wires shall undergo a process of degreasing pickling in acid, cold rinsing and then galvanizing.

INSTALLATION OF CABLE TRAYS

Cable trays shall be installed generally at the elevations shown in respective cable tray layout drawings. If any major modifications in the drawings are envisaged in the field, these should be carried out after getting approval from design office.

Before laying the trays, contractor shall submit the shop drawing & take the approval from client/Project Manager.

It shall be the responsibility of the electrical contractor to mark up all the field modifications on the latest issues of the drawings and return two copies of all such "as constructed" drawings to client/Project Manager's design office.

The type and size of tray to be used shall be as mentioned in the individual layout drawings.

Cable trays shall be welded to the mounting/carrier structures. Trays shall be supported with suitable angle/hitech rod supports.

Each continuous laid out length of cable tray shall be earthed at minimum two places by GI flats of minimum size 25x6 mm (unless otherwise noted) to the Employer's earthing system. The distance between earthing points shall not exceed 10 meters.

The following shall be checked before laying the cables on trays.

- Check for proper identification nos. of the trays.
- Check for continuity of cable trays over the entire route.
- Check that all sharp corners, burrs, and waste materials have been removed from the tray.
- Obtain clearances from piping contractor / engineer that no piping will be taken in the way of cable trays.
- Check for earth continuity & earth connection of cable trays.

Cable tray installation work shall comply with all currently applicable statutes, regulations, and safety codes in the locality/country where the installation is to be carried out.

8. VARIABLE FREQUENCY DRIVES- VFD

SCOPE

This specification covers the requirements of Variable Frequency Drive for efficient and trouble-free operation.

CODES AND STANDARDS

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations, and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

GENERAL REQUIREMENTS

This specification covers complete variable frequency drives (VFD's)

The frequency converter shall not be a general purpose product, but a dedicated HVAC engineered product. Brand labelled Drives are not acceptable.

The VFD and its options shall be factory mounted and tested as a single unit under full load before dispatch.

The VFD shall be tested to UL 508C. The appropriate UL label shall be applied.

The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive

The VFD shall be UL listed for a short circuit current rating of 100 kA and labelled with this rating.

The VFD shall have factory assembled C2 filter and harmonic filter

The VFD shall be IP-55 Protection with Inbuilt Disconnect Switch .

VFD Shall have inbuilt semiconductor fuse with a completely sealed design.

The VFD shall have in-built I/O card to meet the I/O points as per BOQ/SLD.

TECHNICAL REQUIREMENTS

The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor derating. When properly sized, the VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. VFD's utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation

The VFD shall be with active front end technology i.e IGBT based Inverter & IGBT based converter with inbuilt LCL filter meeting THDi guideline of less than 5% as per IEEE 519 standard at drive input without external additional harmonic filter for ratings 4kW and above. IGBT Based design with LC filters and without DC Bus Capacitors are not acceptable .

The VFD shall include an input full-wave bridge rectifier and maintain a fundamental (displacement) power factor near unity regardless of speed or load.

VFDs shall have a dedicated Voltage boost feature to ensure full torque even when the input supply Voltage is below nominal rated voltage.

All VFD's shall contain integral EMC Filters to attenuate Radio Frequency Interference conducted to the AC power line. The VFD's shall comply with the emission and immunity requirements of IEC 61800-3: 2004, Category C2 with 100m motor cable (unrestricted distribution). The suppliers of VFD's shall include additional EMC filters if required to meet compliance to this requirement.

The VFD's full load output current rating shall meet or exceed the normal rated currents of standard IEC induction motors. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds every 600 seconds and 120% of rated torque for up to 0.5 second while starting.

The VFD shall provide full motor torque at any selected frequency from 20 Hz to base speed while providing a variable torque V/Hz output at reduced speed. This is to allow driving direct drive fans without high speed derating or low speed excessive magnetization, as would occur if a constant torque V/Hz curve was used at reduced speeds.

A programmable automatic energy optimization selection feature shall be provided as standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings – AEO is part of VFD

The VFD must be able to produce full torque at low speed to operate direct driven fans

Output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD.

An Automatic Motor Adaptation algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to perform the test – AMA is part of VFD

Galvanic isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFD's not including either galvanic or optical isolation on both analog I/O and discrete digital I/O shall include Additional isolation modules

VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD operation while reducing motor noise. VFD's with fixed carrier frequency are not acceptable. Default Switching frequency shall be 3KHZ or above as per IEC TS 60034-25 and the manufacturers Shall Confirm the same .if Switching frequency is less than 3KHZ then necessary derating has to be considered to size the VFD to 3KHZ.

The VFD shall allow up to at least 100 meters of SWA (Single Wire Armour) cable to be used between the FC and the motor and allow the use of MICS (Mineral Insulated Copper Sheath) cable in the motor circuit for fire locations

PROTECTIVE FEATURES

A minimum of Class 20 I2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed and should ensure protection as per IEC 60947-4-1. The VFD should have built in overload function with thermal memory retention and speed sensitivity

Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable

Protect VFD from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost

Protect from under voltage. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage range 380 V to 480 V , -15% to +10%

VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost

If the temperature of the VFD s heat sink rises to 80 C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD s temperature becomes too high

In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping

The VFD shall have Speed controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running

Protect from output switching: The VFD shall be fully protected from switching a contactor / isolator at the output with out causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans / pumps near the motor with VFD in ON mode

When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take appropriate protective action when one of the above situations is detected

INTERFACE FEATURES

Hand, Off and Auto keys shall be provided on the control panel to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protect them from undesired operation –

There shall be an Info key on the keypad. The Info key shall include online context sensitive assistance for programming and trouble shooting.

The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System

Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes.

All VFD's shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFD

The VFD display for be capable of taking screenshots for instantaneous events with alphanumeric Graphical display

Drive shall be provided with Bluetooth enabled Control Panel for wireless interface with mobile phones / PDA

To set up multiple VFD's, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFD's in turn and download the setup parameters to each VFD. To facilitate setting up VFD's of various sizes, it shall be possible to download from the keypad only size independent parameters. Keypad shall provide visual indication of copy Status

Display shall be programmable to communicate in multiple languages including English.

Fault and Warning indications shall be visible both on the keypad as well as the keypad removed

A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD. The VFD shall also have individual Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications

A two feedback PID controller to control the speed of the VFD shall be standard. VFDs with PI Controllers are not acceptable as they will not provide accurate response

This controller shall accept up to two feedback signals. It shall be programmable to compare the feedback signals to a common set point or to individual set points and to automatically select either the maximum or minimum deviating signal as the controlling signal. It shall also be possible to calculate the controlling feedback signal as the average of all feedback signals or the difference between a pair of feedback signals

The VFD shall be able to apply individual scaling to each feedback signal

For fan flow tracking applications, the VFD shall be able to calculate the square root of any or all individual feedback signals so that a pressure sensor can be used to measure air flow. The VFD's PID controller shall be able to actively adjust its set point based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the controlled system

The VFD shall have three additional PID controllers which can be used to control damper and valve positioners in the system and to provide set point reset.

Floating point control interface shall be provided to increase/decrease speed in response to contact closures

Five simultaneous meter displays shall be available. They shall be selectable from (at a minimum), frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, feedback signals in their own units, among others

Programmable Sleep Mode shall be able to stop the VFD. When its output frequency drops below set sleep level for a specified time, when an external contact commands that the VFD go into Sleep Mode, or when the VFD detects a no-flow situation, the VFD may be programmed to stop. When the VFD's speed is being controlled by its PID controller, it shall be possible to program a wake-up feedback value that will cause the VFD to start. To avoid excessive starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD

A run permissive circuit shall be provided to accept a system ready signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output run request signal to indicate to the external equipment that the VFD has received a request to run

VFD shall be programmable to display feedback signals in appropriate units, such as inches of water column (in-wg), pressure per square inch (psi) or temperature (°F). Examples can be room temperature in °C, return air temperature in °C, supply air temperature in °C, CO2 concentration in ppm, pressure in bar, differential pressure in PSI etc

VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication

Standard Control and Monitoring Inputs and Outputs

Six dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry

Two Three programmable relay outputs, Form C 240 V AC, 2 A, shall be provided for remote indication of VFD status.

Each relay shall have an adjustable on delay / off delay time.

Two programmable analogue inputs shall be provided that can be either direct-or-reverse acting.

Each shall be independently selectable to be used with either an analog voltage or current signal.

The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 V dc and 0 to 20 mA.

A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.

The Analog input terminals shall be of 12-bit resolution for improved accuracy.

The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and trouble shooting,

One Two programmable analog current output (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output. Xi. It shall be possible to read the status of all analog and digital inputs of the VFD through serial bus communications

It shall be possible to command all digital and analog output through the serial communication bus

Optional Control and Monitoring Inputs and Outputs

It shall be possible to add optional modules to the VFD in the field to expand its analog and digital inputs and outputs.

These modules shall use rigid connectors to plug into the VFD s control card.

The VFD shall automatically recognize the option module after it is powered up. There shall be no need to manually configure the module.

Modules may include such items as:

Additional digital outputs, including relay outputs

Additional digital inputs

Additional analog outputs

Additional analog inputs, including Ni or Pt temperature sensor inputs

It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD.

Standard programmable fire-fighter s override mode allows a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFD shall display FIREMODE whenever in fire-fighters s override mode. Fire mode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards and conditions.

A real-time clock shall be an integral part of the VFD without any optional card.

It shall be possible to use this to display the current date and time on the VFD s display

Ten programmable time periods, with individually selectable ON and OFF functions shall be available. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter set points and output relays. Is shall be possible to program unique events that occur only during normal work days, others that occur only on non-work days, and others that occur on specific days or dates. The manufacturer shall provide free PC based software to set up the calendar for this schedule

All VFD faults shall be time stamped to aid troubleshooting

It shall be possible to program maintenance reminders based on date and time, VFD running hours, or VFD operating hours.

The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log

The VFD shall be able to store load profile data to assist in analyzing the system demand and energy consumption over time.

The VFD shall include a sequential logic controller to provide advanced control interface capabilities. This shall include:

Comparators for comparing VFD analog values to programmed trigger values

Logic operators to combine up to three logic expressions using Boolean algebra

Delay timers

A 20-step programmable structure

The VFD shall include a Cascade Controller which allows the VFD to Operate in closed loop set point (PID) control mode one motor at a controlled speed and control the operation of 3 additional constant speed motor starters

SERIAL COMMUNICATIONS

The VFD shall include a standard EIA-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:

Bacnet MSTP

Modbus RTU

VFD shall have standard USB port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system

The VFD shall have provisions for an optional 24 V DC back-up power interface to power the VFD s control card if there is a dedicated 24V SMPS Supply at site. This is to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost

ADJUSTMENTS

The VFD shall have a manually adjustable carrier frequency that can be adjusted in 0.5 kHz increments to allow the user to select the desired operating characteristics. The VFD shall also be programmable to automatically reduce its carrier frequency to avoid tripping due to thermal loading.

Four independent setups shall be provided. Four preset speeds per setup shall be provided for a total of 16. Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 3,600 seconds 0 to 1,800 seconds. Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If desired, it shall be possible to program a timer which will cause the VFD to trip off after a programmed time period. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, current limit, over temperature, and VFD overload. The number of restart attempts shall be selectable from 0 through 20 0 through 5 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds. An automatic start delay may be selected from 0 to 120 seconds. During this delay time, the VFD shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired.

Four Three programmable critical frequency lockout ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment shall be provided. Semi-automatic setting of lockout ranges shall simplify the set-up.

OPTIONAL FEATURES

All optional features shall be built and mounted by VFD manufacturer as an inbuilt factory solution. All optional features shall be UL listed by the VFD manufacturer as a complete assembly and carry a UL label.

SERVICE CONDITIONS –

Ambient temperature at full speed, full load operation with continuous drive rated output current:

10 to 40°C for all ratings without derating

Relative Humidity: 0 to 95%, non-condensing.

Elevation: Up to 3,300 feet without derating.

AC line voltage variation: + 10% of nominal with full output.

VFD Enclosure protection: IP21.

IP21 protection drive for VFD panel mounting applications

Side Clearances: No side clearance shall be required for cooling.

All power and control wiring shall be done from the bottom.

All VFD's shall be plenum rated.

QUALITY ASSURANCE

To ensure quality, the complete VFD shall be tested by the manufacturer. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.

All optional features shall be functionally tested at the factory for proper operation.

VFD CONFIGURATION SOFTWARE

The VFD manufacturer shall provide PC based software configuration for the VFD. This software shall allow Client employees to setup, configure, document and diagnose the VFD, in order to enhance the VFDs functionality and to minimize Client's dependence on outside sources for both setup and maintenance. The software shall be a Windows based program for computers with Windows based operating systems.

Communication: The software shall be capable of communicating with the VFD and the factory automation system by means of acceptable digital communications protocols.

Communication link between the VFD Control Panel and the BMS shall be provided to make all the status / parameters in the Logic Control Panel of VFD. For this purpose, the HVAC Contractor shall provide all necessary hardware and software at the VFD control panel end to make available the data in any one of BacNet, Lon or ModBus protocols. The HVAC Contractor shall provide all engineering data such as address and data list, type of connection, baud rates, handshake, parity, etc. to the BMS Contractor. The HVAC Contractor shall also provide the looping / interlinking of the Pumps microprocessor based panels. The BMS Contractor shall provide all necessary hardware and software at the BMS end and also the interconnecting cable between the VFD panel and the BMS. In case of multiple makes / models of the pump panels, as many links as required for each make / model shall be provided by the BMS Contractor and the HVAC Contractor shall loop each make / model's panels. The BMS Contractor shall use the engineering data provided by the HVAC Contractor to implement the communication link. The BMS supplier shall perform all engineering including and up to generation of graphic pages, reports, alarms, etc. to display the status / parameters.

9. FANS / LIGHT FIXTURES & ACCESSORIES

This specification covers the design, material, specification, manufacture, testing, inspection and delivery to site of lighting fixtures (luminaire) with lamps and their associated accessories. This specification does not cover requirements of lighting suitable for aerodromes, hospitals, road traffic signals and mines.

CODES & STANDARDS

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of execution of the works unless otherwise specified. The revisions in the relevant codes and standards after the date of award of contract shall be informed by the Contractor to the Consultant/ Owner within 30 days of the issue of such revision of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed. In case of conflicts between the standards and this specification, the more stringent of the two shall govern.

LIGHTING FIXTURES (LUMINAIRE) – GENERAL REQUIREMENTS

Luminaire shall be designed for continuous trouble-free operation under atmospheric conditions as specified in Sections B & C of project information without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and water-proof type.

For each type of luminaire the BIDDER shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.

All luminaire shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage and frequency indicated in Data Sheet.

Luminaire shall meet all the power quality and safety requirements as required by relevant IS. All luminaire shall also be compatible with power quality existing at site.

Fluorescent type, incandescent type, mercury vapour, sodium vapour, LED and metal halide type luminaire shall be complete with accessories like lamps, ballasts, Driver, power factor improvement capacitors, starters, etc. These shall be mounted as far as possible in the luminaire housing only. If these cannot be accommodated integral with the luminaire then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop-out connections. Outdoor type fixtures shall be provided with outdoor type weather-proof box with IP 55 or better.

Each luminaire shall have a terminal block suitable for loop-in, loop-out and T-off connection by 1100 V, 1 core, PVC insulated copper / aluminium conductor wires upto 4 sq.mm in size. In outdoor, corrosive and hazardous areas the termination at the luminaire shall be suitable for 1100 V, PVC insulated, copper / aluminium conductor, armoured cables of size upto 6 sq.mm conductor. Terminals shall be of stud or clamp type. The internal wiring shall be completed by the MANUFACTURER by means of stranded copper wire of minimum 1 sq.mm size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws. Mounting facility and conduit knock-outs for the luminaire shall be provided.

All hardware used in the luminaire shall be suitably plated or anodised and passivated for use in chemical, industrial and power plants.

Entire luminaire, including lamps and accessories, shall be from the green labelled range. Unless otherwise specifically asked, these shall be RoHS compliant. These shall comply with

E-waste (Management) Rules and shall meet the EPR (Extended Producer Responsibility).

EARTHING

Each luminaire and control gear box shall be provided with an earthing terminal suitable for connection to the PURCHASER's earthing conductor of 12 SWG GI wire unless otherwise specified in Data Sheet. All metal or metal enclosed parts of the luminaire / control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

PAINTING / FINISH

All surfaces of the luminaire / control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.

The luminaire housing shall be stove-enamelled / epoxy stove-enamelled/vitreous enamelled or anodised as indicated under various types of fittings. Aluminium paint on flame proof fittings is prohibited.

The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection.

GENERAL REQUIREMENT FOR LED LIGHT FIXTURES

All LED luminaire shall be provided with toughened glass and shall have thickness of sufficient strength and high efficiency prismatic diffuser under the LED chamber to protect the LED and luminaire.

Suitable reflector / lenses may also be provided to increase the illumination uniformity and distribution for LED.

The fixture shall be designed so as to have lumen maintenance of at least 70% at the end of minimum 50000 hours (L70) at design temperature of 35 degree C.

Adequate heat sink with proper thermal management shall be provided such that LED soldering point temperature shall not go beyond 75 degree centigrade.

Minimum view angle of the LED shall not be less than 120 degree.

Power factor of complete fitting shall be more than 0.95 at full load 240V and THD<8%.

The LED luminaire shall be free of glare. Colour rendering index (CRI) shall be ≥ 75 . System luminous efficacy for indoor area shall be ≥ 80 .

The luminaire shall be provided with inbuilt surge protection of not less than 4 kV to prevent damage to the driver in case of sudden voltage surge.

Lumen maintenance report as per LM 80 guidelines shall be produced for the LEDs used. The test report shall contain description of the source tested/Ambient Condition (Airflow, Temperature etc.)/Electrical Condition/Lumen Maintenance Data/Observation of failure (Lumen depreciation monitored every 1000 hours)/LED Monitoring Interval/Chromaticity shift over time. The LED chips shall have system luminous efficacy of 100 lm/W or more and LED fixture shall have system efficacy of 70 lm/W or more.

Bidder shall submit LM 79 (Electrical & Solid State measurement of solid state lighting products/fixtures). The test report shall contain Total lumen output of the fixture/luminaire intensity distribution/electrical power/luminous efficacy/colour characteristic of the fixture i.e. CCT & CRI.

Each luminaire shall be provided with an earthing terminal suitable for connection to the Bidder's Stamp & Initials

PURCHASER's earthing conductor of 12 SWG GI wire unless otherwise specified.

Well glass luminaire:

Well glass luminaire shall be robust construction, cast aluminium / vitreous enamelled housing, clear heat and shock resistant glass cover fixed with EPDM gaskets for sealing. For mechanical protection to the glass cover, MS wire – guard with vitreous enamelled finish shall be provided. Additional heavy gauge vitreous enamel anodized aluminium reflector shall be provided. Luminaire for indoor use shall be with degree of protection IP 54.

When used semi-outdoors the luminaire shall be with minimum degree of protection IP 65 and is generally used in steam generator area, platforms etc.

When used in coal dust and hazardous areas classified under zone 2 Groups IIA, IIB, IIC the luminaire shall be increased safety, intrinsically safe, dust proof, dust tight and vapour proof with degree of protection with IP65 or better and mercury vapour lamps.

- (a) The housing shall be cast aluminium (LM6) or cast iron / stove enamelled with porcelain lamp holder, stove enamel reflector, heat resistant toughened glass cover complete with wire guard, EPDM gaskets, suspension hook or strap, side 2 way cable entry, earthing terminal, etc.
- (b) The luminaire shall have relevant CIMFR or other statutory authority certification for use in zone 2 areas.

LED LUMINAIRE

Low/Medium/High bay LED Luminaire housing shall be die cast aluminium and anodized aluminium reflector with polyester powder coat finish or polyester white paint finish. Diffuser shall be made of Polycarbonate material. Luminaire shall have heat sink for better thermal dissipation

Bulkhead LED Luminaire housing shall be die cast aluminium with front cover of polycarbonate diffuser.

General purpose flood light luminaire:

Flood light luminaire shall be of weather proof construction with die-cast aluminium housing, anodised aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary EPDM gaskets to prevent ingress of dust, moisture and insect.

The housing shall be supported on a cast iron / aluminium base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.

For focussing purposes, knobs shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.

When mercury vapour, sodium vapour or metal halide lamps are specified, the same shall be mounted in a separate sheet metal enclosed / cast aluminium weatherproof control gear box.

Flame proof flood light luminaire shall be with die cast aluminium housing, stove enamelled, having degree of protection with IP65 or better and used in hazardous areas classified under zone 1 and 2 areas where gas groups IIA and IIB are specified.

The luminaire shall be complete with stove enamelled anodized aluminium reflector, porcelain lamp holder, heat resistant toughened glass cover, cast iron mounting base, cable gland, earthing terminal etc.

The luminaire shall have relevant CIMFR or other statutory authority certification for use in zone 1 or 2 areas.

The Flood light LED luminaire shall be housed in die cast aluminium and corrosion resistant powder finish and shall have toughened glass diffuser with integral driver.

Induction floodlight luminaire shall be with dimmable controlgear & dimming system based on time switch.

OUTDOOR LANTERN LUMINAIRE

POST TOP LANTERN

Post top lantern luminaire shall be generally outdoor weatherproof type for illumination of walkways, gate posts, gardens etc.

The luminaire shall have cast aluminium spigot finished with corrosion proof paint for mounting, opal acrylic or high-density polyethylene (HDP) diffuser bowl, complete with integral mounted control gear, neoprene gaskets, earthing terminal, etc.

The Lantern LED luminaire shall be housed in die cast aluminium and powder coated finish.

LUMINAIRE FOR SPECIAL APPLICATION

AVIATION OBSTRUCTION/WARNING LUMINAIRE

Aviation Obstruction Light shall be LED type luminaire (low, medium, high intensity) with long life. The luminaire and related system shall conform to ICAO guidelines.

This luminaire shall be with weatherproof, die cast aluminium body with shock resistant clear glass dome for better illumination. The luminaire and driver shall be suitable for outdoor application. The degree of protection shall be IP65 or better.

AOL shall be suitable for lamp exchange period of over 15 years, with maintained intensity.

Automatic Bypass system shall be provided, in the luminaire, for series of LEDs of each luminaire.

AOL shall be complete with all accessories, hardware, fixing arrangement, internal wiring, termination box and bottom cable gland/conduit entry.

The system shall be integrated with Astronomical Time Switch and Photocell.

The means for attaching the luminaire shall be designed to suit the weight of the luminaire and strength to withstand wind speeds as applicable to particular area as per relevant IS.

Low Intensity type luminaire shall be suitable for mounting on structures / buildings upto 45 metres height.

Low intensity (minimum 10 candela in red, minimum 90 candela luminous intensity - total 360deg integrated) red coloured clustered LED type aviation obstruction/warning lights (AOL) The AOL shall be steady glowing (without any flashing). AOL shall have min. 10Cd maintained intensity over a period of >15 years.

Medium Intensity type luminaire shall be suitable for mounting on structures / buildings upto 200 metres height.

This system shall consist of a beacon with medium intensity red coloured fixed/flashing OR white coloured flashing LED lamps.

High Intensity type luminaire shall be suitable for mounting on structures / buildings of height 200 metres and above.

This system shall consist of a beacon with LED lamps emitting high intensity white light and synchroniser flasher unit.

ENVIRONMENTAL LIGHTING LUMINAIRE**Bollard Luminaire**

- (a) Bollard luminaire shall be outdoor, weather proof type for illumination of lawns, gardens, pathways, etc.
- (b) The luminaire shall be of die cast aluminium housing, clear acrylic cover, louvers for directing light downwards and bottom cable entry.
- (c) The luminaire shall be suitable for LED.

PORTABLE EMERGENCY LIGHT LUMINAIRE

- (a) Emergency light shall be indoor type for providing emergency light during failure of normal AC supply.
- (b) The luminaire shall be with CRCA sheet steel enclosure, complete with metallised mirror reflector, leak proof re-chargeable battery, rated for two hour discharge, battery, charger, charger-on lamp, push button switches, automatic changeover switch / relay, two metre length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire.
- (c) The luminaire shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal AC supply the luminaire shall pick-up automatically and on restoration of AC supply the luminaire shall switch off automatically.
- (d) The luminaire shall be suitable for required incandescent lamp and fluorescent lamp.

CLEAN ROOM LUMINAIRE

- (a) Clean room luminaire shall be suitable for the application. These shall be easy to clean. These shall be Bottom opening / Top-Opening depending on the project specific installation practice. The surface finish & Material of construction shall avoid any microbial growth such as bacterial/Viral/Fungal.

ACCESSORIES FOR LUMINAIRE**REFLECTORS**

The reflectors shall be made of CRCA sheet steel / aluminium / silvered glass/ chromium plated sheet copper as indicated for above mentioned luminaire.

Aluminium used for reflectors shall be anodized / epoxy stove enamelled / mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings and or in Data Sheet.

Aluminium paint on the reflectors of flame proof lighting fittings is prohibited.

Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient such as to ensure the overall light output specified by the MANUFACTURER.

Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing

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by means of positive fastening device of captive type.

TESTS AND TEST REPORTS

Type tests, acceptance tests and routine tests for the lighting fixtures and accessories covered by this specification shall be carried out as per the relevant standard for the respective fixtures and their accessories.

The MANUFACTURER's type and routine test certificates shall be submitted for tests conducted as per relevant standards for the fixtures and accessories. The BIDDER shall submit with his proposal copies of available test certificates of the luminaire offered.

DRAWINGS AND DATA

As part of proposal, the BIDDER shall furnish relevant descriptive and illustrative literature on lighting fixtures and accessories and the following drawings / data for the respective lighting fixtures.

Dimensioned drawings with manufacturer's catalogue numbers.

Lumen maintenance report as per cl.no.3.10.9

Information called for in Data Sheet for each group of luminaire.

In addition to the above bidder to refer the control switch gears & accessories specification also for this section.

LIGHTING AUTOMATION

The Lighting Management System(LMS) and associated equipment including HMI, photocells, timers, astronomical time clocks, etc., shall comply with the latest applicable IEC / IS standards. The control system shall be designed and manufactured to comply with the CE Standard.

The lighting Automation control system shall include but not be limited to the following:

- Floor controller in electrical risers
- Wired Ceiling mounted sensors;
- Wired Photocells;
- Wired ELV switches;
- Ethernet Cable between Ethernet Modules and already existing LAN network.
- Twisted pair cable between floor controllers, and other items, accessories, hardware, software, etc., as required for a complete stand-alone lighting control and monitoring system.
- The lighting control system shall be capable of working with an array of differing lamp sources with following
 - Logical Grouping / patching requirements
 - Scene-setting requirements
 - Daylight Tracking Requirements
 - System Graphic Topology
 - Required IP Router
 - Touch Switches
 - AREA / LINE COUPLER Dali Gateway
 - Dali controller Tunable White

Software Control and Monitoring Functions

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These software functions will be executed by Building Management Systems which needs to have all the feature mentioned.

Detailed engineering of the system shall be carried out by the vendor.

Central Automatic Control Functions

Central automatic commands are to be generated by a calendar software program. The calendar program enables different switching and scene regimes to be allocated for different times of the day or year and programming of weekend and special event planning. Timing software shall include as standard an astronomical time clock.

The system shall be capable of providing a load shedding facility such that each luminary circuit can be designated an essential (operable during loss of mains) or nonessential (held off).

Scene's reflecting time of day and daylight in zones can be automatically controlled via the central commands.

The system shall be capable of providing corridor linking linked to occupation of adjoining spaces and is held on while associated areas are in use.

The system shall provide complete daylight linking to enable energy savings to be achieved when adequate daylight is provided.

The lighting control system shall record the numbers of hours run by each switchable group of lighting; this information will be used for monitoring lamp life and producing planned maintenance schedules.

A global input from a number of photoelectric cells forming part of the general lighting shall be used to operate the general lighting installations, the external lighting installations.

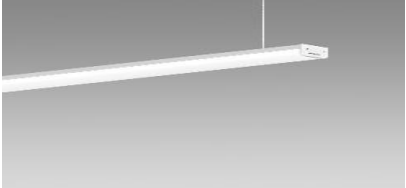
The layout of the buildings shall be shown on the workstation graphics in plan form and shall show the major components of the general lighting system. Navigation buttons/icons shall allow the lighting control zones of the center to be displayed at larger scales and give control of individual lighting circuits.

The system shall be capable of producing planned maintenance schedules. The system shall provide a management tool for monitoring status and historical performance of the sub-project and load center.

Integration capability:

This Lighting Management System should be capable of integrating with Building Management System on Bacnet / IP or KNX IP Interface.

Note : Listed out the Light fittings reference images and type – Specification of all fixtures shall be followed as per BOQ .

Description As per BOQ	Reference Image
(TYPE1 LIGHT FIXTURE)	
(TYPE2 LIGHT FIXTURE)	
(TYPE3 LIGHT FIXTURE)	
(TYPE4 LIGHT FIXTURE)	
(TYPE5 LIGHT FIXTURE)	
(TYPE6 LIGHT FIXTURE)	

TYPE7 LIGHT FIXTURE)		
(TYPE8 LIGHT FIXTURE)		
(TYPE9 LIGHT FIXTURE)		
(TYPE10 LIGHT FIXTURE)		
(TYPE11 LIGHT FIXTURE)		
(TYPE12 LIGHT FIXTURE)		

10. SWITCHES, SOCKETS & ACCESSORIES

This specification covers the design, material, manufacture, testing, inspection, and delivery to site the Indoor and Outdoor lighting system equipment. The indoor equipment includes lighting distribution boards, panels (Single phase/Three phase), switches, power receptacle units, lighting wires, junction box, conduits and its accessories, ceiling fans etc, the outdoor equipment includes outdoor lighting distribution boards/panels, lighting poles (Street light/Flood light/High mast), LT power cables, etc. Separate specification when enclosed, cover the requirements of lighting system installation works.

CODES & STANDARDS

The items of supply shall conform to the latest applicable electrical rules, all currently applicable standards codes of practice indicated in Data Sheet, regulations, and safety codes of the locality where the equipment are to be installed. In case of conflict between these standards and specification, the more stringent of the two shall govern. Nothing in this specification shall be construed to relieve the CONTRACTOR of his responsibility. Where no standards are available, the supply items shall be backed by test result, shall be of good quality and workmanship and any supply items which are bought out by the VENDOR shall be procured from approved manufacturers acceptable to the PURCHASER/ENGINEER.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of execution of the works unless otherwise specified. The revisions in the relevant codes and standards after the date of award of contract shall be informed by the Contractor to the Consultant/ Owner within 30 days of the issue of such revision of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the Statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

The CONTRACTOR shall ensure that instruments and gauges to be used for testing and inspection of critical parameters as identified in the specification have valid calibration and the accuracy can be traced to National/International standards, as applicable.

LIGHT CONTROL SWITCHES

Light control switches of ratings and types, i.e. decorative/industrial/flame proof, shall be supplied as indicated in project layout drawings/price schedule. The switches shall be suitable for use on 240 V, 1 phase, 50 Hz supply.

Switches shall be of flush type for mounting behind an insulated plate or incorporated with a switch or switch box/suitable enclosure. The switch box/ enclosure may be recessed into or mounted on wall as per the requirements of project layouts.

The size of enclosure boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be made of 1.2 mm thick CRCA sheet steel, stove enamelled/galvanised. The enclosure box shall be covered with perspex/insulating cover. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

Flame proof switch shall be of rotary type construction, enclosed in a flame proof enclosure and rated for 15 Amps. As a standard feature, unless otherwise specified, switch shall have two bottom entries, one of which shall be provided with a flame proof stopper plug.

RECEPTACLE UNITS

Receptacle units shall consist of socket outlet with associated switch, neon indicating lamp and plug. The socket outlet and switch or MCB shall be flush mounted within a stove enamelled/ galvanised 1.2 mm thick CRCA sheet steel enclosure with perspex/insulating cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.

The outdoor type receptacles shall be housed in a 2 mm thick CRCA sheet steel epoxy painted enclosure with gasketed, hinged door having locking arrangement. The enclosure shall be with rain canopy and removable gland plate entry from bottom. Composite receptacle with switch modules housed in a box shall be with degree of protection IP 66.

The receptacle units shall be suitable for 240 V, 1 phase, 50Hz/415V, 3 phase, 50 Hz supply as indicated in project layout drawings/price schedule.

Single phase receptacles shall be associated with a switch/MCB of same current rating and the receptacle shall become live only when the associated switch/MCB is in "ON" position.

Three phase receptacles shall be associated with a TPN switch housed in the same enclosure. The receptacle shall become live only when the associated switch is in "ON" position and it shall not be possible to withdraw the plug with the switch in "ON" position.

The plugs shall be provided with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

The types and current ratings of receptacle units shall be as indicated in the Project layout drawing/price schedule and they shall conform to the applicable standards indicated in Data Sheet.

FLAMEPROOF EQUIPMENT

The enclosure of all flameproof equipment for use in hazardous areas where gases/vapours of Group I, IIA, IIB, IIC are present, shall be of cast iron/cast aluminium, stove enamel finished. Chemical corrosion resistant epoxy finish shall be provided, if specified in Data Sheet. The construction shall comply with relevant applicable standards mentioned in Data Sheet.

If the enclosures are additionally required to be weatherproof, neoprene gaskets shall be provided to make the enclosure dust and weather proof providing a degree of protection of IP 55.

All ferrous parts, exposed to atmosphere shall be suitably plated/galvanised.

All internal wiring shall be connected to terminal blocks provided in terminal enclosure on incoming side.

Flameproof cable gland entries shall be provided suitable for the PURCHASER's specified cable sizes. The number of required cable entries for junction/terminal boxes as required for branching, terminating of cables for lighting distribution shall be provided. All unused cable entries shall be closed by flameproof plugs.

Flameproof receptacle unit (socket with associated switch/MCB and plug) shall have interlocking feature such that plug cannot be inserted or taken out with switch/MCB in "ON" position.

Two external earthing terminals shall be provided on the enclosure to suit the PURCHASER's specified conductor. Additionally, one internal earthing terminal shall be provided in junction/terminal boxes.

Adequate mounting lugs with necessary hardware shall be provided for mounting the Bidder's Stamp & Initials

equipment on wall/structure.

These enclosures shall have inscription warning against opening the enclosure unless the circuit is isolated. Equipment rating and ON/OFF positions of switches/MCBs shall also be designated.

The BIDDER shall indicate that the enclosures have been tested and certified by relevant Statutory authorities for use in hazardous areas.

CEILING FANS / WALL MOUNTED FANS

Ceiling/Wall mounted fans shall be suitable for operation on 240 V, 1 phase, 50 Hz supply and shall be complete with standard mounting accessories such as suspension rods, top and bottom caps etc for ceiling fans and easy accessibility for wall mounted fans. The fans shall be supplied with appropriate speed regulators.

The fans shall generally conform to the applicable standards indicated in Data Sheet-. Details regarding blade sweep and suspension requirements shall be as per Project layout drawing/price schedule.

LIGHTING WIRES

The wires for wiring in lighting system shall be 1100 V, 1 core, PVC insulated, unarmoured with stranded copper conductors, unless otherwise specified in Data Sheet. The wires shall conform to the applicable standards specified in Data Sheet- .

The minimum area of conductors shall be 2.5 sq.mm for light fittings and 5A receptacles and 4 sq.mm for receptacles rated 15 A.

The wires shall be coded white for phase/positive of DC and black for neutral/ negative of DC.

The approximate quantities of wires shall be indicated by the PURCHASER in Data Sheet only when the same are not covered in the CONTRACTOR's "Point Wiring" work under lighting system installation work.

CONDUITS

Rigid steel/non-metallic conduits and their associated fittings shall conform to applicable standards in Data Sheet- . The minimum size of conduit shall be 20 mm for surface installation and 25 mm diameter for concealed installation.

Steel conduits shall be seamed by welding and hot dip galvanised unless otherwise specified. They shall be supplied in standard lengths of 5 m.

Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting installation work. In case of building with expansion joints, it shall also include junction boxes with flexible connectors for expansion joints.

The approximate quantities of conduits shall be indicated by the PURCHASER only when conduits are not covered in the CONTRACTOR's "Point Wiring" work under lighting system installation works.

JUNCTION BOXES

Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc.

The junction boxes shall be dust and vermin proof and shall be fabricated from 1.2 mm to 2 mm thick mild steel plate. The junction boxes shall be dust and vermin proof and shall be fabricated from 1.2 mm to 2 mm thick mild steel plate.

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mm CRCA sheet steel depending on the size of the junction box and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof when specified.

The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, HRC fuses, as indicated in the Project drawing.

The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be minimum 650 V grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type.

The boxes shall be hot dip galvanised/painted with one shop coat of red oxide zinc chromate primer followed by a finishing coat of paint as specified.

SPARE PARTS

Unit prices of the items listed in Data Sheet shall be quoted together with catalogue numbers.

The VENDOR may recommend additional spare items and quote the unit prices of the respective items.

TESTS AND TEST REPORTS

Type tests, acceptance tests and routine tests for all supply equipment/ component parts covered by this specification shall be carried out as per the relevant standards for the respective equipment and their accessories.

The certified copies of test certificates/reports of the above-mentioned tests shall be submitted to the PURCHASER before dispatch of equipment. BIDDER shall submit with his proposal copies of available type test certificates of the equipment/component parts offered.

DRAWINGS AND DATA

The BIDDER shall furnish relevant technical/ descriptive literature of all quoted items and the general arrangement drawing showing dimensioned views for Lighting Distribution boards and lighting panels and junction boxes. Data Sheet completely filled in shall also be furnished.

FOR REVIEW/APPROVAL

Distribution board/Panel general arrangement dimensioned drawings showing plan elevation and side view, outline dimensions, floor openings, floor/wall/ structure fixing arrangements, earthing terminals and weights etc

Bill of material listing component/equipment designation, make, type, ratings, quantity of the various components mounted on the boards/ panels.

Schematic wiring diagram of the distribution boards/ panels, showing the terminal numbers and the terminals for the PURCHASER's external connections.

Dimensional drawing of flood lights tower giving all design particulars, GA drawing of High Mast.

FOR INFORMATION

Inside view of distribution boards / panels showing mounting and wiring arrangement of various component equipment.

Descriptive/technical catalogues of air break switches, MCCB, miniature circuit breakers, residual current circuit breakers, metering instruments, light control switches, receptacle
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units, flameproof enclosures, conduits, junction boxes and ceiling/wall mounted fans.

Dimensioned drawing of flood lights tower/High mast giving all design particulars shall be submitted for approval before fabrication of the tower/High mast.

11. WIRING

For WIRES please refer to the respective local state PWD specifications. In the absence of information from PWD specification, the following specifications shall be followed as given below.

The specification covers design, manufacturing, supply, installation, testing and commissioning of internal wiring / conduit wiring for modular switch sockets, Lighting fixtures and lighting control equipment.

CODES AND STANDARDS

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

SYSTEM OF WIRING

The system of wiring shall consist of PVC insulated copper stranded conductor flexible FRLS (Fire Retardant Low smoke) wires in metallic / non metallic (Rigid heavy Duty ISI - marked fire retarded PVC Conduits of minimum 2mm Wall thickness and Sizes starting from 20 mm diameter) conduits and shall be concealed or surface mounted above false ceiling as called for.

GENERAL

Prior to laying and fixing of conduits, the contractor shall mark the conduit route, carefully examine the working drawings prepared by him and approved route, sufficiency of number and sizes of conduits, location of junction boxes, sizes and location of switch boxes and other relevant details. Any discrepancy found shall be brought to the notice of the Owner's site representative. Any modifications suggested by the contractor should get written approval before the actual laying of conduits is commenced.

In laying of conduits, it is important that not more than two right angle bends are provided for each circuit without a pull box. No junction box shall be provided in the entire length of conduit run for drawing of wires. Only switch outlets, lighting fixture outlets, equipment power outlets and socket outlets shall be considered for drawing of wires. Wiring for short extensions to outlets in hung ceiling or to vibrating equipments like motors etc, shall be installed in flexible conduits with necessary glands of same material at both the ends. No flexible extension by the Consultant indicating the layout, satisfy himself about the non-interference in the

METAL CONDUITS & ACCESSORIES.

- Conduits and Accessories shall conform to latest edition of Indian Standards IS-9537 part 1 & 2.16/14 (16 gauge up to 32mm diameter & 14 gauge above 32 mm diameter) gauge screwed GI or MS painted conduits as specified in the design basis shall be used.
- Joints between conduits and accessories shall be securely made by standard accessories, as per IS-2667, IS-3837 and IS-5133 to ensure earth continuity.
- All conduit accessories shall be threaded type only. Only approved make of conduits and accessories shall be used.
- Conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

- Note.: Whatever materials required to be billed by the Contractor should come on site with proper Challan Numbers and quantity mentioned in each such Challan.
- All jointing shall be subject to the approval of the Owner's site representative. The threads and sockets shall be free from grease and oil. End termination of conduit on GI boxes shall be by means of hexagon check nuts & spring washer on both sides of the conduit. The joints in conduits shall be free of burrs to avoid damage to insulation of conductors while pulling them through the conduits. Rubberised bushes shall be used in the conduit entry and exit from DBs, switch boxes etc, so that wires are protected from damage to insulation of the incoming and outgoing wires.
- All conduits shall be as per Schedule of quantities .
- For all exposed (areas without false ceiling) wiring shall be with -GI conduit, & above the false ceiling areas the wiring shall be in- MS conduits shall be used.
- Flexible conduits shall be made of heavy gauge MS strip galvanized after making the spiral. Both edges of the strip to have interlocking to avoid opening up. Flexible conduit shall be heat resistant, lead coated steel, water leak, fire and rust proof. The flexible conduit shall be heat resistant on continuous temperature up to 150 deg. C and intermittent temperature up to 200 deg. C. The flexible conduit shall be corrosion resistant as per IS-3480 & BS-731.

PVC CONDUITS & ACCESSORIES.

PVC Conduit

Conduits and accessories shall conform to latest edition of IS-9537 part 3 and shall be heavy duty with minimum wall thickness of 2.0 mm rigid tubes which are unscrewed without coupling and with plain ends. All PVC conduits used shall be Fire Retardant, ISI-marked and shall not be less than 20 mm diameter. Heavy duty FR PVC conduit shall be used for all concealed / embedded installation.

PVC Conduit Accessories

Accessories used for conduit shall be of an approved brand and type complying to relevant IS code. All accessories used shall be of standard white or black colour, identical to conduit used .Plain conduits shall be joined by slip type of couplers with manufacturer's standard sealing cement.

All conduit entries to outlet boxes, trunking and switchgear are to be made with adaptors female thread and screwed male bushes. PVC-switch and socket boxes with round knockouts are to be used. The colours of these boxes and the conduits shall be the same.

Standard PVC circular junction boxes are to be used with conduits for intersection, Tee junction, angle-junction and terminal. For the drawing-in of cables, standard circular through boxes shall be used.

Samples of accessories shall be submitted for approval prior to installation. All jointing of PVC conduits shall be by means of adhesive jointing. Adequate expansion joints shall be allowed to take up the expansion of PVC conduits.

BENDS

Where necessary, bends or diversions may be achieved by means of bends and / or circular cast iron boxes with inspection cover and with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction box shall be provided with a cover properly secured and flush with the finished wall surface. No bends shall have radius less than 7.5 cms or three times the outside diameter of the conduits. For metallic conduits, bends of defined radius shall be made by compactly filling fine sand inside the conduit length, to avoid non-uniform shape, once the bend is done. Proper jigs shall be used to ensure that the Enamelling /Galvanising of the Conduit is not damaged.

FIXING OF CONDUITS

All conduits shall be installed so as to avoid exposure to steam, hot water or any other process pipes. After the conduits, junction boxes, outlet boxes and switch boxes are installed in position, their outlets shall be properly plugged or covered so that water, mortar, rodents and insects, insects or any other foreign matter does not enter into the conduit system.

Surface conduits shall be fixed by means of heavy gauge GI saddles secured at intervals not more than 1000 mm and on either side of couplers or bends or similar fitting saddles shall be fixed at a distance of 300 mm from centre of each fitting. For conduit fixing suitable PVC/Nylon fasteners shall be used.

Recessed conduiting shall be done by making chase in the masonry by chase cutter; the conduit shall be fixed in the chase by means of GI hooks not more than 600 mm apart. After fixing of conduit the chase shall be filled with cement mortar after fixing of chicken mesh and brought to the original finish level of the surface to the entire satisfaction of Owner.

SWITCH OUTLETS , JUNCTION BOX OUTLETS & INSPECTION BOX

All outlet boxes for switches, sockets and other receptacles shall be rust proof and shall be of 1.6 mm thick mild steel sheets with HOT dipped galvanizing (or as specified in SOQ), having smooth external and internal surfaces to true finish. All outlet boxes for receiving plug sockets and switches shall be fabricated to approved sizes. All boxes shall have adequate number of knock out holes of required diameter and earthing terminal screws. Outlet boxes shall generally be of 50mm depth subject to maximum depth of 65 mm.

DRAWING OF CONDUCTORS

The drawing and jointing of PVC insulated copper conductor wires shall be executed with due regard to the following precautions. While drawing wires through conduits, care shall be taken to avoid scratches and kinks which may cause breakage of conductors.

There shall be no sharp bends. Wire reel stands to be used for pulling of wires to avoid kinks. Care shall be exercised while drawing the wires from reels, by taking appropriate measures to ensure that wires are not spread on ground, causing dust and dirt accumulation on the new wires.

Maximum permissible number of 1100 volt grade PVC insulated FRLS wires that may be drawn into metallic Conduits are given below:

Size of wires Nominal Cross section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	5	10	14	--	--
2.5	5	8	12	--	--
4	3	7	10	--	--
6	2	5	8	--	--
10	--	3	5	6	--
16	--	2	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

Maximum permissible number of 1100 volt grade PVC insulated FRLS wires that may be drawn into rigid non-metallic or FR PVC Heavy duty Conduits are given below :

Size of wires Nominal Cross section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	7	12	16	--	--
2.5	5	10	14	--	--
4	4	8	12	--	--
6	3	6	8	--	--
10	--	4	5	6	--
16	--	3	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

Insulation shall be removed by insulation stripper only. Few Strands of wires shall not be cut/reduced for convenience in connecting into terminals. At each terminal of wire, lugs to be mounted using appropriate crimping devices. The terminals shall have sufficient cross-sectional area to take all strands and it's connecting brass screws shall have flats ends. All looped joints shall be connected through terminal block/connectors. The pressure applied to tighten terminal screws shall be just adequate, neither too much nor too less. All light points shall be terminated through a connector. Conductors having nominal cross-sectional areas exceeding 10 sq.mm shall always be provided with cable sockets. At all bolted terminals brass flat washer of large area and approved steel spring washer shall be used. Brass nuts and bolts with brass washers shall be used for all connections.

Only licensed wiremen (Before doing the work or before appointing him on site contractor has to submit his wiring licence to Owner) and cable jointers shall be employed to do jointing work. Before entrusting cable jointing work to any technician, or before appointing Cable Jointers or Wiremen on Site, Contractor has to submit such Technicians' / Wireman's / Cable Jointer's licence to Owner. All wires and cables shall be embossed with the manufacturer's label with ISI mark and shall be brought to site in original packing. For all internal wiring, PVC insulated wires of 1100 volts grade (LSZH) shall be used.

The sub-circuit wiring for point shall be carried out in loop system and no joints shall be allowed in the length of the conductors. No wire shall be drawn into any conduit until all defective work of conduit installation of any nature that may cause injury to wire is completed. Care shall be taken while pulling out the wires so that no damage occurs to conduits/wire itself, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction. The minimum size of PVC insulated copper conductor wires for all sub-circuit wiring for light points shall be minimum 2.5 sq.mm copper. Separate neutral to be pulled for each circuit.

MAINS & SUBMAINS

Mains and sub-mains cable or wires where called for shall be of the rated capacity and approved make. Every main and sub main wires shall be drawn into an independent adequate size of conduit. Earthing shall be in conformity with relevant IS codes and calculations shall be submitted for verification. An independent earth wire of the proper ratings shall be provided for every single phase sub-main. For every 3 -phase sub-main, 2 Nos. earth wires of proper rating shall be provided along with the sub-main.

The earth wires shall be drawn along with circuit wires through conduit. Where mains and sub-mains cables are connected to switchgear, sufficient extra lengths of cable shall be provided to facilitate easy connections and maintenance. Powder-coated 1.6 mm thick sheet steel covering (also called trunking) shall be provided to cover the group of conduits and cables entering and exiting the Wall mounted/Floor mounted Sub DBs, DBs, and FDBs, so that the Installation looks neat. The colour of such sheet steel covering (trunking) shall be matching with the colour of the SDBs, DBs and FDBs.

Balancing of circuits in three phase installation shall be as planned by the ELECTRICAL contractor in the shop drawings and shall be checked by the owner \ owner's representative before the commencement of wiring and shall be strictly adhered to.

MEASUREMENT OF POINT WIRING

Unless specified otherwise, measurement for point wiring for lighting circuits shall be on the basis of primary and secondary point. As mentioned in Schedule of Quantities. All work & materials necessary for wiring a point circuit of any length from the Final Distribution Board to switch board shall include the circuit wiring except where identified.

Point wiring shall be measured in units of number. or set as describe in schedule of quantities. It is including all wiring, back box, earthing wires, conduits, conduit supporting structural members including spacers, clamps etc, bushes and other fittings as well as flanges (with gaskets, nuts, and bolts for jointing), unions, bends, elbows, tees, concentric and / or eccentric reducers, inspection pieces, expansion loops etc (as required for completing installation.).The above accessories shall be measured as part of circuit cum point wiring as specified in schedule of quantities.

12. AUXILIARY POWER SUPPLY

The specification covers design, manufacturing, supply, installation, testing and commissioning of auxiliary supply for substation equipments.

CODES AND STANDARDS

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

BATTERY SIZING

The nominal voltage of a single cell shall be 1.2 V. Battery capacity shall be adequate to cater for continuous load (annunciation, indicating lamps etc.) as well the maximum momentary load that may arise due to tripping of all HT breakers connected to bus.

The supplier shall carry out battery sizing calculations based on the load cycle specified in line with IEEE 1115.

Following factors shall be considered while carrying-out battery sizing calculations.

- Ageing factor – 1.25
- Design margin –1.0
- State of charge –0.9

The number of cells shall be determined as per load cycle and the battery system. Voltage level & adequate no of spare cells.

BATTERY CHARGER UNIT FOR SMF BATTERY**General**

The battery charger shall be two Float cum Boost type Thyristor controlled. The charger shall have selector switch for Auto Float – Boost / Manual Float / Manual Boost Mode of operation. During Auto Float – Boost Mode, Automatic Changeover shall take place from Float Mode to Boost mode and Vice-Versa. This means that when the Batteries are fully charged the charging shall automatically change from Boost charge to trickle charge. One battery charging set shall be provided with two identical charging units each capable of functioning as float cum boost charger as well as supplying the DC load. Transformer neutral and enclosure earthing of Battery chargers shall have separate dedicated earthing conductor and shall be connected to main earthing grid.

Construction Feature

Float cum Boost charger and DC Distribution Board shall be housed in sheet steel cubicle (IP 42 rating) with panels of 1.6 mm thickness, louvers for ventilation glands plate will be provided for cable entry from bottom. The cubicle shall be painted in Siemens grey shade RAL-7032. The battery charger is divided into two compartments. The upper compartment houses the battery charger with all the necessary controls. The lower compartment is suitable for housing the batteries. Separate charge bus and load bus shall be provided. Normally both the chargers, the battery and the load shall be connected to the load bus, the charger being on float mode. During boost charging, charger shall be connected to the charge bus with the battery. During this period, it shall be ensured that the other charger is healthy and connected to the load bus through contactor changeover arrangement. In case, the contactor fails, audio visual alarm shall be generated and subsequently the healthy charger shall feed the total load.

Performance

The D.C output voltage of Float / Boost charger shall be stabilized within + 5% for AC input variation of 230 V + 10%, frequency variation of 50 Hz + 5% and DC load variation of 0-100%. The voltage regulation shall be achieved by a constant voltage regulator having fast response SCR control. The ripple content will be within 3% of DC output nominal voltage. Battery chargers shall be design for operating ambient temperature of 0°C- 50°C.

There shall be provision to select Auto Float / Manual Float / Manual Boost modes.

During Auto Float Mode the battery charging shall automatically changeover from Boost Mode to Float Mode and Vice Versa. During Manual Float / Boost modes it shall be possible to set the output volts by separate potentiometers.

The battery charger shall have automatic output current limiting feature.

In case of main AC power failure with the battery on float charge mode, the battery shall be automatically connected to the load bus for feeding of all loads. When power supply is resumed, then the charger, pre-selected as boost charger, shall start boost charging the battery until the desired battery voltage is reached. During this period, the load bus shall be isolated from the charge bus and the other charger shall feed the load.

In case of main AC power failure during boost charging of the battery, the battery shall be automatically connected to the load bus by a DC contactor. During the time of closure of the auto changeover contactor, the continuity of power supply shall be maintained from the tap cell of the battery through suitable diodes.

During the period of boost charging, if the float charger fails, then the boost charger shall get connected to the load bus automatically through the dropper diodes to feed the load. Normally, the dropper diodes shall remain by passed by suitable normally closed DC dropper diode bypass contactor. During the time of opening /Closing of the auto changeover contactors, the continuity of power supply shall be maintained from the tap cell of the battery through suitable diode. Boost charger shall be designed to cater DC continuous load as well as desired constant current for charging the battery simultaneously. The voltage at the load terminals shall be kept within specified limit through proper selection of dropper diodes.

During the period of boost charging, if the boost charger fails, then the mode of operation of the float charger shall automatically change from float to boost and charger shall start boost charging the battery as well as go on feeding the load through dropper diodes.

Facility shall be provided to manually connect the battery to the charge bus and switch on the selected boost charger when the battery voltage falls below a preset level and charge the battery at a constant recommended starting current upto recommended cell voltage level.

The Charger shall be suitable for supplying the normal (100%) constant load and at the same time maintain the battery to which it is connected in a full charged condition while floating across the load and charger.

DC Distribution Board

It shall be provided in the charging cubicle, it will comprises of the following:

Incoming : Bidder to specify

Outgoing : 10 Nos. 16 A DP MCB

(Bidder to be submit the sizing calculation of battery chargers as per load profile and finalise DB configuration depend on the same.)

Test

All equipment and components thereof shall be to factory tests as per relevant IS standards. The following tests shall be conducted.

- a. Dielectric Test.
- b. Voltage regulation check from 0 to 100% load with $\pm 10\%$ input voltage variation
- c. Ripple content measurement
- d. Heat Run Test on current limiting values.
- e. Routine Tests on component parts.

VRLA SMF BATTERY CHARGER FOR SUBSTATION**General**

The battery charger shall be Float cum Boost type Thyristor controlled. The charger shall have selector switch for Auto Float – Boost / Manual Float / Manual Boost Mode of operation. During Auto Float – Boost Mode, Automatic Changeover shall take place from Float Mode to Boost mode and Vice-Versa. This means that when the Batteries are fully charged the charging shall automatically change from Boost charge to trickle charge.

Performance

The D.C output voltage of Float / Boost charger shall be stabilized within + 2% for AC input variation of 230 V + 10%, frequency variation of 50 Hz + 5% and DC load variation of 0-100%. The voltage regulation shall be achieved by a constant voltage. regulator having fast response SCR control. The ripple content will be within 3% of DC output nominal voltage.

There shall be provision to select Auto Float / Manual Float / Manual Boost modes. During Auto Float Mode the battery charging shall automatically changeover from Boost Mode to Float Mode and Vice Versa. During Manual Float / Boost modes it shall be possible to set the output volts by separate potentiometers. The battery charger shall have automatic output current limiting feature.

Construction Feature

Float cum Boost charger and DC Distribution Board shall be housed in sheet steel cubicle with panels of 1.6 mm thickness, louvers for ventilation glands plate will be provided for cable entry from bottom. The cubicle shall be painted in Siemens grey shade RAL-7032. The battery charger is divided into two compartments. The upper compartment houses the battery charger with all the necessary controls. The lower compartment is suitable for housing the batteries.

Rating (for 24 V Battery Charger)

AC Input : 230 V + 10% AC 50 Hz single phase.

DC Output : To float cum boost charge of 24 V with suitable

AH batteries and also supply a continuous load.

Current Rating : 30.0 Amps

Float Mode : 27.0 V nominal (Adjustable) between 24-28.0 V.

Boost Mode : 28.2 V nominal (Adjustable) between 24-29.0 V.

Voltage Regulation : + 2% for AC input variation of 230 V + 10%.

Frequency Variation of 50 Hz + 5% and DC load variation 0-100%

Ripple : Less than 1%

DC Distribution Board

It shall be provided in the charging cubicle, it will comprises of the following:

Incoming : 1 No. 63 A DP MCB

Outgoing : 10 Nos. 16 A DP MCB

VRLA BATTERY CHARGER FOR SUBSTATION**General**

This specification covers the requirements for 24 V, VRLA type batteries with chargers. The latest state of the art Valve Regulated Sealed Maintenance Free Lead Acid Batteries with suitable discharge rating. The batteries covered in this specification are for indoor use. For out-door application suitable enclosure shall be provided.

Battery Sizing

Battery capacity shall be adequate to cater for actual burden of relay and metering load & momentary load that may arise due to tripping of all breakers connected to bus.

The battery system design shall be provided with necessary devices to prevent deep discharge beyond recommended limits to prevent the batteries discharging beyond end cell voltage specified by the battery maker.

Following factors shall be considered while carrying-out battery sizing calculations.

a) Ageing factor – 1.25

b) Design margin –1.0

c) State of charge –0.9

The number of cells shall be determined as per load cycle and the battery system.

Voltage level & adequate no of spare cells.

Construction

Separators provided in the batteries shall be fibre boron on silicate glass mat. It shall be spill proof and vibration proof. The container of VRLA type battery shall be flame retardant.

Insulation of inter cell connectors for batteries shall be FRLS type and also the battery terminals shall have FRLS shroud (anti-static type).

All batteries shall be clearly identified and identification numbers marked on the batteries and a schematic diagram.

Connectors

The connections from battery to battery shall be by using heavy duty copper bus bar strips and terminal post shall be of brass of least electrical resistance. All terminals and cell inter-connectors shall be fully insulated or have insulation shrouds.

Terminals

Separate terminals shall be provided on the end cell for connecting load through DCDB and for connecting charger leads. All terminals shall be of suitably sized.

Battery Racks

Suitable corrosion resistant battery racks and cable supports shall be provided. Metallic racks shall be properly earthed. The bottom tier of stand shall have a ground clearance of 150mm minimum above the floor. Racks shall be made of alkali resistant powder coated steel or stainless steel or FRP to ensure corrosion resistance.

Temperature Range

Battery must be capable of continuous operation in temperatures range of -15 oC to +50oC for prolonged periods. No Air-conditioning shall be provided where batteries are to be installed.

SAFETY EQUIPMENT

Danger Plate

Danger plate shall be provided on HV and MV equipment. MV danger notice plate shall be 200 mm x 150 mm made of mild steel atleast 2 mm thick with vitreous enamelled white on both side and with inscription in red colour on front side.

Fire Extinguishers

Portable CO2 conforming to IS:2878-1976, and dry chemical conforming to IS:2171-1967 shall be provided in the Sub-station.

For outdoor duty power transformers, stand alone type CO2 fire extinguisher \ sand buckets etc shall be provided.

Insulating Mats for Electrical Purpose

Insulating Mats shall be in compliance with IS-15652-2006 /IEC 61111-2002-06.

The insulating mats shall be made of Elastomer (a generic term that includes rubber, latex and elastomer compounds that may be natural or synthetic or a mixture of both) for use as floor covering for the protection of workers on AC and DC installation with the system voltage up to 66 KV AC and 240 volts DC.

Mats shall be resistant to acid and oil and low temperatures and shall be identified by the respective class symbol.

Thickness of mats for different classes, physical properties, dielectric properties and all other specification shall be as per IS:15652-2006. be free from blisters, pin holes, cracks, embedded foreign matters and other defects.

First Aid Box

First Aid box shall be provided with all necessary medicine, bandage, scissor etc.

13. EARTHING & LIGHTNING PROTECTION

This specification covers the requirements of installation, testing and commissioning of earthing systems. The work shall be carried out in accordance with this specification, relevant project layout drawings, typical drawings and installation notes enclosed with the specification.

CODES AND STANDARDS

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

GENERAL

The system shall be TNS with four wire supply system (R,Y,B,N and. E) . All the non-current carrying metal parts of electrical installation and all metal conduits trunking, cable sheaths, switchgear, distribution panels, light fittings and all other parts made of metal shall be bonded together and connected by means of specified earthing conductors to an efficient earthing system.

All metal work such as pipelines, ducts, cable trays, stair case railing etc shall be bonded to earth. All earthing shall be in conformity with IS: 3043 1987, and the basic system of earthing shall be TNS. Earthing for electronic equipment shall follow IEEE 1100 recommendations.

EARTH CONDUCTORS

Earthing conductors shall be of copper for equipment neutral earthing, IT equipment earthing, Server / Hub rack earthing, Isolation transformer neutral earthing etc. as per BOQ. GI conductor shall be used for general body earthing as mentioned in the design basis. Conductor shall be protected against mechanical injury and corrosion.

SIZING OF EARTH CONDUCTORS

Sizing of earth conductor for HV equipment and main LV panels etc. shall be based on actual fault current calculated. Separate earthing grids shall be provided for body earthing, neutral earthing of transformers & electronic \ IT equipment for every group of building. Earthing grids for all building groups shall be connected together at ground floor for equipotential bonding & to minimize overall resistance of earthing path.

Earthing grids of electronic \ IT equipment shall be separate & shall not be connected to general earthing grids. Electronic \ IT equipment earthing grids for all building blocks shall be interconnected for equipotential bonding & to minimize overall resistance of earthing path. For lighting & power circuits cross sectional area of earthing conductor shall not be smaller than half of the largest current carrying conductor subject to an upper limit of 80 Sq.mm. If the area of the largest current carrying conductor or bus bar exceeds 160 sq.mm then two or more earthing conductors shall be used in parallel, to provide at least half the cross sectional area of the current carrying conductor or bus bars. All fixtures, outlet boxes, junction boxes and power circuits up to 15 amps shall be earthed with PVC insulated copper wire.

CONNECTION OF EARTH CONDUCTORS

All joints in tapes shall be with four rivets and shall be brazed in case of copper and by welding or bolting in case of GI. Wires shall be connected with crimping lugs; all bolts shall have spring washers. Sub- mains earthing conductors shall run from the main distribution panel to the sub distribution panel. Final distribution panel earthing conductors shall run from sub-distribution panel.

Circuit earthing conductor shall run from the exposed metal of equipment and shall be connected to any point on the main earthing conductor, or its distribution panel. Metal conduits, cable sheathing and armouring shall be earthed at the ends adjacent to distribution panel at which they originate, or otherwise at the commencement of the run by an earthing conductor in effective electrical contact with cable sheathing. Where equipment is connected by flexible cord, all exposed metal parts of the equipment shall be earthed by means of an earthing conductor enclosed with the current carrying conductors within the flexible cord. Switches, accessories, lighting fitting etc. which are rigidly secured in effective electrical contact with a run of metallic conduit shall not be considered as a part of the earthing conductor for earthing purposes, even though the run of metallic conduit is earthed. The installation shall be complete in all respects for efficient and trouble-free service. All work shall be carried out in a first-class quality and neat workmanship.

Grounding conductors shall be handled carefully to avoid kinking and cutting of the conductors during their installation. All exposed ground conductors run shall be taken in a neat manner horizontal, vertical and parallel to the building walls or columns and shall not be laid haphazardly. All connections to the grounding grid shall be made with earthing strip welded to grid and bolted at equipment ends.

Neutral conductor, sprinkler pipes, or pipes conveying gas, water or inflammable liquid, structural steel work, metallic enclosures, metallic conduits and lightning protection system conductors shall not be used as a means of earthing an installation or even as a link in an earthing system. The electrical resistance measured between earth connection at the main LT panel and any other point on the completed installation shall be low enough to permit the passage of current necessary to operate or circuit breakers and shall not exceed 1 ohm.

All switches carrying medium voltage shall be connected with earth by two separate and distinct connections. The earthing conductors inside the building wherever exposed shall be properly protected from mechanical injury by running the same in G I pipe of adequate size.

The overlapping in strips at joints where required shall be minimum 75 mm. The joints shall be riveted and brazed in case of copper and by welding / bolting in case of GI in an approved manner. Sweated lugs of adequate capacity and size shall be used for termination of all conductor wires above 6 sq.mm size. Lugs shall be bolted to the equipment body to be earthed after the metal body is cleaned of paint and other oily substances and properly tinned. Equipotential bonding of all metallic structures shall be done.

The following must always be ensured in earthing system.

There shall be separate and distinct grid for the electronic IT equipments UPS neutral, Rack earthing, Isolation transformers etc.

Separate grid shall be created for generator neutrals, transformer neutrals, lightning protection system earth pits etc. Separate grid shall be provided for body earthing of all electrical equipment. These earth grids shall be interconnected at the ground level to form a common grid.

Extraneous conductive parts such as gas pipes, other service pipes and ducting risers and pipes of fire protection equipment and exposed metallic parts of the building structure.

Earth resistivity test to be done by ELECTRICAL contractor to establish correct values and use the same for calculating overall earth resistance.

Resistance to Earth The resistance of earthing system shall not exceed 1 ohm.

HOT DIP GALVANISING PROCESS**Quality of Zinc**

Zinc to be used shall conform to minimum Zn 98 grade as per requirement of IS:209-1992.

Coating Requirement

Minimum weight of zinc coating for mild steel flats with thickness upto 6 mm in accordance with IS:6745-1972 shall be 400 g/sqm.

The weight of coating expressed in grams per square metre shall be calculated by dividing the total weight of Zinc by total area (both sides) of the coated surface.

The Zinc coating shall be uniform, smooth and free from imperfections as flux, ash and dross inclusions, bare patches black spots, pimples, lumpiness, runs, rust stains bulky white deposits, blisters.

Mild steel flats / wires shall undergo a process of degreasing pickling in acid, cold rinsing and then galvanizing. Jointing of earthing tape shall be by welding. All joints and cut ends shall be properly painted with aluminium paint.

CONVENTIONAL COPPER EARTH ELECTRODE

Earthing electrode shall be 600 x 600 x 3.15 mm thick tinned copper plate electrode, with 2 Nos 50 x 6 mm copper strips from earth plate electrode to inspection chamber, 50 mm dia medium class GI pipe, CI funnel with 20 gauge GI wire mesh, masonry chamber 1000 x 500 mm with concrete base as per IS3043 with C I heavy duty / chequered plate manhole cover with frame painted with bitumastic paint and packing with mixture of charcoal and common salt around plate electrode including digging of pit upto permanent moisture level and as per soil condition but not less than 3 meters and back filling as required.

CONVENTIONAL GI EARTH ELECTRODE

Earthing electrode shall be 600 x 600 x 6.3 mm thick GI plate electrode, with 2 nos. 50 X 6 mm GI strips from earth plate electrode to inspection chamber, 50 mm dia medium class GI pipe, CI funnel with 20 gauge GI wire mesh, masonry chamber 1000 X 500 mm with concrete base as per IS3043 with CI manhole cover with frame painted with bitumastic paint and packing with mixture of charcoal and common salt around plate electrode including digging of pit upto permanent moisture level but not less than 3 meters and back filling as required.

CHEMICAL EARTH ELECTRODE

In maintenance free earthing copper bonded earthing rod electrode shall be of 14.35 mm in diameter and 3 meter length. The rod shall be placed in a 150 mm dia augured hole in the ground and then surrounded by ground enhancement material in either a dry form or pre mixed in a slurry. Once set, ground enhancement material becomes hard and as such holds positively to the rod as well as surrounding ground.

Earth rod offered shall have passed the test required of BS7430/ ANSI/ UL467 and confirm to the adhesion of the copper coating to the steel core (Design feature that prevents the ingress of moisture and subsequently the integrity of the rod. Minimum 0.25 mm thickness of copper shall be deposited over the steel core as per BS 7430/ UL 467. Average life of the ground rod shall be 30 years in most soil.

Ground enhancement material shall be as per IEEE-80 clause 14.5d with a resistivity of less than 0.12 ohm-meter. The ground enhancement material shall be permanent and not leach any chemicals in to the ground. The pH value of the ground enhancement material shall be 6.9 to 7.2 of 100 gm/ lit @ 20 deg.C.

Minimum 30 Kg of ground enhancement material shall provided for each earth electrode. Inspection chamber shall be of 400 x 500 mm with concrete base CI manhole cover with Bidder's Stamp & Initials

frame painted with bitumastic paint. 2 Nos. of 50 x 6 mm cross section & 300 mm long copper strip to be clamped with copper clad rod electrode have sufficient nos (But not less than 4 Nos.) of 10 mm GI nuts & bolts for connection to the equipment / interconnection to the other pits to form equip-potential bonding.

GENERAL REQUIREMENTS OF LIGHTNING PROTECTION SYSTEM.

The lightning protection air termination rods and / or horizontal air termination conductors shall be fixed in such a way that they remain in their installed position even during severe weather conditions. The necessary accessories such as cleats, clamps, welding materials, bolts, nuts, shall be supplied by CONTRACTOR.

Air termination system shall be connected to earthing system below ground by down conductors as shown in various project drawings. For this purpose separate treated earth pit to be constructed. The down conductors shall follow a direct path to earth. There shall not be any sharp bends, turns and kinks in the down conductors.

All joints in the down conductors shall be of welded / brazed type. All metallic structures within 2 meters from down conductors shall be bonded to lightning protection system.

The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, cable conduits and metal enclosures of electrical equipment. However all metal projections, railings, vents, tanks etc. above the roof shall be bonded together to form a part of roof grid.

In case structural columns are being used as downcomers then continuity shall be ensured from the horizontal roof conductor to the column through rafter, purlin etc. Necessary flexible jumpers shall be provided if required. Such columns shall be connected to an independent earth pit at the ground level. If rain water down take pipes are available then the downcomers from horizontal roof conductor can be taken clamped to the rain water pipe Steelwork within reinforced concrete structures is considered to be electrically continuous provided that the major part of interconnections of vertical and horizontal bars are welded or otherwise securely connected. Connections of vertical bars shall be welded, clamped or overlapped a minimum of 20 times their diameters and bound or otherwise securely. For structures utilizing steel reinforced concrete (including pre-cast, pre-stressed reinforced units), the electrical continuity of the reinforcing bars shall be determined by electrical testing between the uppermost part and ground level.

The overall electrical resistance should not be greater than 0.2 Ohms measured using test equipment suitable for this purpose. If this value is not achieved, or it is not practical to conduct such testing, the reinforcing steel shall not be used as a natural down-conductor.

CONVENTIONAL TYPE LIGHTING PROTECTION SYSTEM

Conductors shall be securely fixed on the terrace by means of air terminal holder which is fixed on the roof by adhesive of good quality taking care of varying weather conditions. Air conductor holder is an insulator & should be of minimum 50 mm height so that even small amount of water logging on terrace is below the level of conductor holder. Air terminal holder shall not be more than 0.5 m apart for a flat conductor & 1m for round conductor of at least 8mm diameter & 1.0 meter apart for vertical run.

Recommended distance between air terminal holders. If antenna, air cooler or any other electrical equipment is present above terrace level, the same have to be protected by using vertical air terminal after calculating the safety or separation distance. The vertical air terminal has to have suitable supports to hold it. Vertical air terminal must be connected to horizontal air terminal by using suitable connectors.

At the crossings of the horizontal air terminals, suitable T or Cross connector has to be used for secure connection.

Arrangement	Recommended distance for SOLID TAPE	Recommended distance For ROUND conductors
Horizontal conductor on horizontal surface.	500 mm	1000 mm
Horizontal conductor on vertical surface	500 mm	1000 mm
Vertical conductor from Ground to 20m height	1000 mm	1000 mm
Vertical conductor above 20m height	500 mm	1000 mm

The lightning protective system shall have as few joints. As far as possible, air terminal & down conductor have to be straight. Where it is not possible, it should NOT be bent at 90 degrees (right angles) & should have a curved path of 45 degree.

In order to reduce the probability of damage to electronic/electrical equipment, the down conductors shall be arranged in such a way that from the point of strike to earth, several parallel current paths should exist & length of the current path should be minimum. Down conductors can be installed separately or more wisely it can be part of natural components of the building Examples are steel reinforcement in RCC columns, metal facades, profile rails, metal doors & windows. Down conductors should be installed at each exposed corner of the structure. Value of distance between down conductors as per Class of Lightning Protection Level.

Test joints:

At the connection of the earth terminal, a test joint should be fitted on each down conductor, except in the case of natural down conductors combined with foundation earth electrode. The purpose of test joint is to measure the earth resistance value.

Earth Terminations:

Earth mat is most preferable. Where earth mat is not possible, ring earthing is the next best method. Ring earthing must be 1 meter away from the building and 0.5m below the ground level. The resistance of earthing system shall not exceed 10 ohms as per IEC 62305. Lower earth resistance is still better.

For earth termination system, 2 basic types of earth electrode arrangements are applicable.

Type A & Type B arrangement.

Type A arrangement: comprises of horizontal or vertical earth electrode installed outside the structure to be protected connected to each down conductor. In type A arrangement, the total number of earth electrodes shall not be less than two.

Type A arrangement is suitable in places where electronic equipment is not located.

Type B arrangement: This type of arrangement comprises either a ring conductor external to the structure to be protected, in contact with the soil for at least 80% of its total length or a foundation earth electrode. Such earth electrodes can also be meshed. For structures with extensive electronic systems or with high risk of fire, type B earthing is most preferable method. Corrosion proofing band has to be used wherever down conductor is connected to earth termination system. Bitumen has to be applied at the point of inter-connection.

Structural lightning protection system

Structural bonding system consists of an additional conductor installed inside an RCC column along with structural steel. The conductor shall be of continuous length from basement to the top of the building. The conductor shall have minimum joints and all joints shall be either connected with suitable connection clamps or exothermically welded for application in columns, soil and under foundation. Clamp joints are permitted only inside concrete / exposed

in air. All conductors for this purpose shall be copper coated and the coating thickness of conductor shall confirm to NBC-2016 and shall be minimum 100 microns.

Exothermic welding if used shall confirm the requirements of IEEE 837. Every component used shall be able to withstand the fault current with minimum temperature rise. The earth studs / earth fixing points should be of Brass – Gun Metal or Stainless steel material and shall be 100 % corrosion resistant and shall confirm the requirements of IEC 62561. Down Conductor for Lightning Protection as well as Bonding conductor for electrical installations (RCC Building) a dedicated 8mm dia copper bonded steel conductor shall run inside columns on the periphery of the building and must be connected to the reinforced steel available in the columns using suitable GUV clamps and will serve the purpose of down conductor for lightning protection as well as base for Equipotential bonding in every floor of a multi-storeyed building. Use of Aluminum is strictly prohibited inside the concrete.

Provisions for interconnection of metal frame of wall cladding and curtain walling shall be provided at every floor level and at suitable horizontal sections in line with the Level of ExLPS design based on the architectural layout. Provision for making this interconnection shall be provided by façade supplier / installer. Stainless steel straps, Clamps in combination with Brass – Gun Metal earth points shall be used for interconnecting the copper banded conductor with Aluminum façade and curtain walling. Testing of down conductor of Structural Earthing used as a part of lightning protection system, overall resistance shall not be more than IEEE norms when measured between the air termination and the earthing test point provided at the ground level.

The air termination system defined above consisting of vertical rods and/or mesh as shown in the drawing and shall be connected to the structural conductor through earth studs / earth fixing points provided at the parapet / columns of the building. For this purpose, sufficient earth studs / earth fixing points with provision of mechanically strong connection need to be provided at the parapet / wall / column at the top of the building. Air termination system shall be installed strictly after completion of the installation of all roof mounted electrical / metal installations.

Installation, Testing and Certification: The total installation need to be carried out by a trained Lightning protection installer having experience in carrying out similar structural lightning protection jobs. The installation also needs to be tested and certified by a qualified lightning protection expert.

A detailed technical training to the user on the installation method need to be made in form of a report for easy reference with earth fixing points marked in the drawing for future identification.

Testing

At the connection of the earth terminal, a test joint should be fitted on each down conductor at a height of 1 m from the ground, except in the case of natural down conductors combined with foundation earth electrode. The purpose of test joint is to measure the earth resistance value. It is recommended to take the test joint at ground level for structural earthing conductors as well and then either can be connected to the foundation earth electrode or taken on the external surface for ring earthing – Type A and B on the external side of the structure in line with IS IEC 62305.

Following type test report shall be submitted,

- Type test report for Earthing Electrode as per IEC 62561-2.
- UL approved Earth Electrode
- Type test report for Earth conductivity enhancing mineral compound as per IEC 62562-7

14. UNINTERRUPTED POWER SUPPLY (UPS)**SCOPE**

The specification covers design, manufacturing, supply, installation, testing and commissioning of modular Un-interrupted Power for emergency power supply for Lighting and Emergency power loads.

CODES AND STANDARDS

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

GENERAL

These special conditions are intended to amplify the General Conditions, and shall be read in conjunction with the same. For any discrepancies between the General Conditions, and these Special Conditions, the more stringent shall apply.

This tender shall act only as a guide to the system desired by the Owners. The specifications described in this tender are based on the "Basis of Design" and are in minimum required from the tenderer.

The system shall be installed by competent technicians & workers approved by the manufacturer/supplier of the equipment. The successful contractor shall furnish a list of workers/technicians approved by the manufacturer/supplier of the system prior to commencement of work. This specification describes the operation and functionality of a continuous duty, three-phase, solid-state, on-line double conversion static Uninterruptible Power System (UPS) hereafter referred to as the UPS. The UPS shall utilize a rack-mounted N+1 module redundant, scalable array architecture. The system power train shall be comprised of power modules and be capable of being configured for N+X redundant operation at the rated system load. In systems operating at a load where the system is N+1 or greater, the UPS shall facilitate the replacement of power modules while the system remains in normal operation, without the requirement to transfer to bypass (hot swappable).

Each power module contains a fully rated, power factor corrected input rectifier / boost converter hereafter referred to as the PFC input stage, a fully rated output inverter, and battery charging, circuit. The system shall also be comprised of Integrated continuous duty bypass static switch module, control modules, redundant logic power supplies, and touch screen user interface/display.

The UPS and associated equipment shall operate in conjunction with a primary power supply and an output distribution system to provide quality uninterrupted power for mission critical, electronic equipment load.
All programming and miscellaneous components for a fully operational system as described in this specification shall be available as part of the UPS.

MODES OF OPERATION

A. Normal: The PFC Input stage and output inverter shall operate in an on-line manner to continuously regulate power to the critical load. The input and output converters shall be capable of full battery recharge while simultaneously providing regulated power to the load for all line and load conditions within the range of the UPS specifications.

B. Battery: Upon failure of the AC input source, the critical load shall continue being supplied by the output inverter, which shall derive its power from the battery system. There shall be no interruption in power to the critical load during both transfers to battery operation and retransfers from battery to normal operation. Upon restoration of utility power to the UPS input, the UPS shall recharge the battery

C. Static Bypass: The static bypass shall be used to provide controller transfer of critical load from the inverter output to the bypass source. This transfer, along with its retransfer, shall take place with no power interruption to the critical load. In the event of a UPS output fault or significant output overload emergency, this transfer shall be an automatic function. Manual transfer to Static Bypass (called "Requested bypass") shall be available in order to facilitate a controlled transfer to Maintenance Bypass.

D. External Maintenance Bypass for > 120 Kva (Part of customer panel and <120kVA part of UPS inbuilt/external): The system can be equipped with an optional integrated, bus connected external make-before-break Maintenance Bypass Cabinet (MBwD) to electrically isolate the UPS during routine maintenance and service of the UPS. The MBwD shall allow for the completely electrical isolation of the UPS. An option for an external make-before-break external maintenance bypass panel shall be available.

SYSTEM REQUIREMENTS

The system input shall be configurable as either single or dual mains derived from a three phase Wye source. Standard cable entry is through the top. Bottom cable entry can also be facilitated. Depending on the specific configuration, the use of the optional Bottom Feed Enclosure may be required. An option shall be available to facilitate the connection of NEMA 2 compression lugs for main input, bypass input, DC input and output cable connections.

SYSTEM INPUTS

- AC Input Nominal Voltage:
 - System voltage shall be selectable at the front panel by service personnel with the following options:
415V
- AC Input Voltage Window:
 - +/-15% for full performance
 - -20% with reduced charge power
 - -50% for reduced load (240V at 480V).

- Short Circuit Withstand Rating: 65,000 Symmetrical Amperes

- Maximum Frequency Range: 40-70Hz

Frequency is synchronized to bypass input when available over the standard range of 57 to 63Hz. Optional frequency tolerance range is configurable from 0.5% to 8% from front panel.

- Input Power Factor:
 - Greater than 0.995 with load at 100%
 - Greater than 0.99 with loads above 50%
 - Greater than 0.97 with loads above 25%

- Input current in Normal operation shall be limited to a maximum of 137% of the system capacity.
- Input current Distortion with no additional filters less than 5%.
- Soft-Start: Shall be linear from 0-100% input current and shall not exhibit inrush. This shall take place over a user selectable 1-60 second time period with a factory default of 10 seconds.

SYSTEM OUTPUTS

- AC Output Nominal Output:
 - System voltage shall be selectable at the graphical user interface by service personnel with the following options: 380V , 400V, 415V and 480 V
- AC Output Voltage Distortion: Less than. 2% @ 100% Linear Load. Less than 6% for SMPS load as defined by EN50091-3/IEC 62040-3
- AC Output Voltage Regulation: +/- 1% For 100 % Linear or Nonlinear Load.
- Voltage Transient Response: +/-5% maximum RMS change in a half cycle at load step 0% to 100% or 100% to 0%.
- Voltage Transient Recovery within <50 milliseconds.
- Output Voltage Harmonic Distortion:
 - <2% THD maximum and 1% single harmonic for a 100% linear load
- Phase Angle Displacement:
 - 120 degrees +/-1 degree for balanced load
 - 120 degrees +/-1 degrees for 50% imbalanced load
 - 120 degrees +/-3 degrees for 100% imbalanced load
- Overload Rating for UPS and Inverter:
 - Normal Operation:
 - 150% for 1 min seconds before transfer to Bypass or
 - 110-125% for 10 minutes before transfer to bypass
 - Battery operation
 - 115% for 30 seconds
 - Bypass Operation:
 - 110% continuous
 - 1000% for 100 milliseconds
 - System AC-AC Efficiency:
 - Normal operation > 97% at 50% - 75% load
 - 96.5% at 25% and 100% load.
 - Output Power Factor Rating:
 - 0.5 leading to 0.5 lagging without any derating

ENVIRONMENTAL

- Storage Ambient Temperature: -15 to 40C (-30 to 70C without batteries)
- Storage relative Humidity: 0-95%
- Operating Ambient Temperature: +45.1°F to 104.4°F (7.3°C to 40.2°C). (77°F is ideal for most battery types).
- Operating Relative Humidity: 0 to 95% non-condensing
- Altitude: Maximum installation with no derating of the UPS output shall be 3,000 feet (1000m) above sea level.
- Audible Noise (as measured three feet from surface) <70 dBA at 100% load

PFC STAGE

The PFC Input stage converters of the system are housed within the removable power modules and shall constantly control the power imported from the mains input of the system, to provide the necessary UPS power for precise regulation of the DC bus voltage, battery charging, and Main Inverter regulated output power. These power modules are connected in parallel within the UPS frame.

Input Current Total Harmonic Distortion: The input current THDI shall be held to less than 5% at system load greater than 50% while providing conditioned power to the critical load bus and charging the batteries under steady-state operating conditions. This shall be true while supporting both a linear or non-linear loads. This shall be accomplished without the requirement for additional or optional filters, magnetic devices, or other components. Rectifier and Inverter design shall be such that the harmonics injected back to the source and to the load shall be within limits specified in IEEE-519 at the point of coupling of the UPS to the system.

Soft-Start Operation: As a standard feature, the UPS shall contain soft-start functionality, capable of limiting the input current from 0- 100% of the nominal input over a default 10 second period, when returning to the AC utility source from battery operation. The change in current over the change in time shall take place in a linear manner throughout the entire operation. Magnetization Inrush Current: The UPS shall exhibit zero (0) inrush current.

OUTPUT INVERTER

The UPS output inverter shall constantly develop the UPS output voltage waveform by converting the DC bus voltage to AC voltage through a set of IGBT driven bi-directional power converters. In both normal operation and battery operation, the output inverters shall create an output voltage independent of the mains input voltage. Input voltage anomalies such as brown-outs, spikes, surges, sags, and outages shall not affect the amplitude or sinusoidal nature of the output voltage sine wave of the inverters.

Overload Capability: The output power converters shall be capable of 200% for 5 sec for short circuit clearing. Steady-state overload conditions, of up to 150% of system capacity shall be sustained by the inverter for 60 seconds in normal operation. Overloads persisting past the outlined time limitation the critical load will be switched to the automatic static bypass output of the UPS.

Output Contactor: The output inverter shall be provided with an output mechanical contactor to provide physical isolation of the inverter from the critical bus. With this feature a failed inverter shall be isolated from the critical bus.

Battery Protection: The inverter shall be provided with monitoring and control circuits to limit the level of discharge on the battery system.

Redundancy: The UPS shall be capable of being configured with redundant output inverters, each with semiconductor fusing, and logic controlled contactors to remove a failed component from the input, DC and output critical bus.

STATIC BYPASS.

As part of the UPS, a system static bypass switch shall be provided. The system static bypass shall provide no break transfer of the critical load from the Inverter output to the static bypass input source during times where maintenance is required, or the inverter cannot support the critical bus. Such times may be due to prolonged or severe overloads, or UPS failure. The UPS and static bypass switch shall constantly monitor the auxiliary contacts of their respective circuit breakers, as well as the bypass source voltage, and inhibit potentially unsuccessful transfers to static bypass from taking place.

The design of the static switch power path shall consist of Silicon Controlled Rectifiers (SCR) with a continuous duty rating of 110% at 415V of the UPS output rating.

Automatic Transfers: An automatic transfer of load to static bypass shall take place whenever the load on the critical bus exceeds the overload rating of the UPS. Automatic transfers of the critical load from static bypass back to normal operation shall take place when the overload condition is removed from the critical bus output of the system. Automatic transfers of load to static bypass shall also take place if for any reason the UPS cannot support the critical bus.

Manual Transfers: Manually initiated transfers to and from static bypass shall be initiated through the UPS graphical user interface.

Overloads: The static bypass shall be rated and capable of handling overloads equal to or less than 110% at 415V of the rated system output continuously. For instantaneous overloads caused by inrush current from magnetic devices, or short circuit conditions, the static bypass shall be capable of sustaining overloads of 1000% of system capacity for periods of up to 100 milliseconds.

Modular: The static bypass switch shall be rated for UPS frame capacity.

DISPLAY

The display unit shall allow the user to display a log of all active alarms. The following minimum set of alarm conditions shall be available:

- Input Frequency outside configured range
- AC adequate for UPS but not for Bypass
- Low/No AC input, startup on battery
- Number of Batteries changed since last ON
- Number of Power Modules changed since last ON
- Number of Power Modules increased
- Number of Power Modules decreased
- Redundancy Restored
- Need Battery Replacement (Applicable only for Hot Swap Battery)
- The Redundant Intelligence Module is in control
- UPS Fault
- On Battery
- Shutdown or unable to transfer to battery due to overload
- Load Shutdown from Bypass. Input Frequency Volts outside limits
- Fault, Internal Temp exceeded system normal limits
- Input Circuit Breaker Open
- System level fan failed
- Bad Battery Module (Applicable only for Hot Swap Battery)
- Bad Power Module
- Intelligence Module is installed and failed
- Redundant Intelligence Module is installed and failed
- Redundancy has been lost
- Redundancy is below alarm threshold
- Runtime is below alarm threshold
- Load is above alarm threshold
- Load is no longer above alarm Threshold
- Minimum Runtime restored
- Bypass is not in range (either frequency or voltage)
- UPS in Bypass due to Internal Fault
- UPS in Bypass due to overload

- System in Forced Bypass
- Fault, Bypass Relay Malfunction
- Q001 open/closed
- Q002 open/closed
- Q003 open/closed
- Q005 open/closed
- High DC Warning
- High DC Shutdown
- Low Battery Shutdown
- Low Battery Warning

UPS BATTERY SYSTEM

The UPS system shall, as an integral part, provide battery system for backup time as specified in the Schedule (Full Load) standby capacity.

The latest state of the art AGM+ FR enclosure Valve Regulated Sealed Maintenance Free Lead Acid Batteries with AGM GEL technology shall be used with a 20 hour discharge rating. Design of batteries should be for 12 years. The charging time of batteries shall be within 8 hours.

The battery system shall be sized to provide backup time as specified in the schedule of quantity when the UPS is supplying 100% rated load at 1 PF load power factor.

An ageing factor of 15% & Crest factor shall be applied to the capacity arrived at, to allow for compensation against capacity loss during float operation.

The battery system design shall be provided with necessary devices to prevent deep discharge beyond recommended limits to prevent the batteries discharging beyond end cell voltage specified by the battery maker. The connections from battery to battery shall be by using copper bus bar strips and the entire battery system shall be used in IP20 steel cabinet enclosure or on shelves and shall be like the UPS enclosure. Separators provided in the batteries shall be fiber boron on silicate glass mat. It shall be spill proof and vibration proof. The container of AGM-GEL VRLA type battery shall be flame retardant.

All batteries shall be clearly identified, and identification numbers marked on the batteries and a schematic diagram along with the complete calculations, including manufacturers supporting curves, shall be submitted with the tender.

The UPS shall have a properly rated and sized circuit breaker to isolate it from the battery.

In modular system, the battery system shall be able to be individual per modules as well be able to be configured as a common battery for a whole n+1 system. Individual battery per module shall be preferred. Insulation of inter cell connectors for batteries shall be FRLS type and also the battery terminals shall have FRLS shroud (anti-static type).

The UPS battery shall support for backup as mentioned in BOQ. Battery charging current shall be temperature compensated. The battery shall be of the valve regulated lead acid (VRLA) type. The latest state of the art 12V AGM FR Valve Regulated Sealed Maintenance Free Lead Acid Batteries with battery life of 2 to 3 years. Warranty of battery shall be as per BOQ requirement.

The following three methods of remote UPS monitoring shall be available:

- Web Monitoring: Remote monitoring shall be available via a web browser such as Internet Explorer.
- Remote UPS monitoring shall be possible via MODBUS
- Simple Network Management Protocol (SNMP): Remote UPS
- Monitoring shall be possible through a standard MIB II compliant

- platform

UPS BATTERY MONITORING SYSTEM

The Battery Monitoring System shall provide for the automatic acquisition, trending, alarming, and storage of information from every cell or jar in a battery bank. It will have the interactive ability to first identify and then provide an isolated equalizing charge current to any individual cell or jar that deviates below a user-specified set point, from the cell average, within the same string or bank.

The Battery Monitoring System shall test the relative charge state and health of each individual cell or jar by injecting a DC current, recording the magnitude of this current & comparing it to previous benchmark values. Systems that require battery discharge for testing are not acceptable. The system shall provide estimated backup time remaining during an actual discharge.

The Battery Monitoring System shall monitor and maintain historical files for:

- Individual cell or jar voltage
- Total bank voltage
- Discharge current
- Ambient and pilot cell temperature
- Relative current response value

Display shall be via local LCD display, with capability for viewing at remote terminal. All files shall be written to a fixed solid-state disk within the enclosure. All functions shall be accessible via modem using common communications software.

The system shall operate a “form C” relay contact when any parameter is in alarm. Alarm data shall be written to a file in ASCII format for future retrieval. The system shall be capable of remote communications for remote access to all functions via modem or ANSI terminal. The Battery Monitoring System shall be capable of monitoring a minimum 264 jars per string, 9 parallel strings per system, 6 cells per jar. Resolution shall be 12-bit accuracy, with up to 10 per second channel test rate. Cell voltage measurements must be made to within plus or minus 5 milli volts over the entire operating and temperature range.

Documentation. Manuals and installation documentation for the equipment shall be provided which lists block diagrams, schematics parts list and theory of operating for each unique component of the system. Installation drawings and documentation shall be site specific for each string at this facility. Marked up building drawings shall be provided to show any changes to building wiring including power wiring and communications cables.

UPS TESTING

The Contractor shall perform the following tests, as a minimum, at site prior to handing over, to confirm the functional and the performance specification of the UPS as specified. All required test equipment like Digital Oscilloscope, Voltage Regulator, Measurement Meters etc. shall be the responsibility of the Contractor without any additional cost.

The Contractor shall demonstrate as a minimum the following features on site by providing all required test equipment, such as power factor improvement, input current THD, output voltage THD, output frequency and all other performance monitoring requirements detailed before as required by the Owner.

The Details of Tests are as mentioned Below;

- Input & output voltage, power factor, frequency and all other performance monitoring requirements
- Input current THD
- output voltage THD

- Full load 24 hour burn in load power test including a 50% battery discharge test
- Overload test for 30 min 110 %, 10 min 125% load & 1 min. at 150% load.
- Demonstrate load shearing, bypass operation & load transfer during outage of one unit
- Load Bank for testing shall be arranged by Contractor.

BATTERY TESTING

The battery-management system shall include the features as given below.

Self-Test. The battery- monitoring system shall include an automatic test for partial discharge. It shall be possible to adjust the frequency of the test. This selftest system shall, where necessary, initiate indications via LEDs on the front panel or a message to a remote monitoring system.

Temperature correction. The battery management system shall automatically adapt the battery voltage to the ambient temperature in order to optimize battery service Life.

Measurement of actual back up time. The battery function shall be combined with a system that continuously monitors the actual back up time available (AC source present) or remaining (AC source absent), according to the actual load on the UPS the battery temperature and the age of the battery.

15. INSTALLATION SPECIFICATION

This specification details the guidelines for work associated with installation, testing and commissioning of various electrical equipment including switchyard equipment. The work shall, however, at all times be carried out strictly as per the instructions of the OWNER/ENGINEER/MANUFACTURER and as per approved drawings where relevant. The scope of work shall be as indicated in Price Schedule.

CODES AND STANDARDS

The electrical equipment installation work shall conform to the latest applicable regulations, currently applicable standards, codes of practice indicated in Data Sheet, regulations and safety codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the CONTRACTOR of his responsibility. In case of conflict between these standards and this specification, more stringent of the two requirements shall govern.

All codes and standards referred to in the specification shall be understood to be the latest version on the date of offer made by the Bidder unless otherwise indicated.

The CONTRACTOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

GENERAL SCOPE

The installation work shall include receipt, unloading at site, shifting from place of unloading/storage to place of installation, assemble all parts of the equipment, erect, test and commission the same

The work shall be carried out strictly as per the instructions and layout drawings of the OWNER/ENGINEER/MANUFACTURER. In case of any doubt/misunderstanding as to correct interpretation of the drawings or instructions, necessary clarifications shall be obtained from the OWNER/ENGINEER. The CONTRACTOR shall be held responsible for any damage to the equipment consequent to not following the instructions correctly. MANUFACTURER's equipment manuals will be furnished to the CONTRACTOR who shall return the same after completion of work.

The CONTRACTOR shall furnish all tools, ladders, scaffolding, welding equipment, rigging materials, testing equipment, test kits etc. required for complete installation, testing and commissioning of the items included in the contract work.

The OWNER may engage specialist engineers from the equipment MANUFACTURERS to supervise the installation, testing and commissioning of their equipment. The CONTRACTOR shall extend full cooperation to these engineers and carry out the works as per their instructions. The CONTRACTOR's work shall include minor rewiring/modifications as may be necessitated during commissioning. Providing such assistance shall be deemed to be included in the CONTRACTOR's basic scope.

The CONTRACTOR shall cooperate through the OWNER/ENGINEER with other CONTRACTORS at site, in all matters of common interest, so as not to obstruct operation of others and to ensure the safety of all personnel and works at the site. In case of any conflict OWNER / ENGINEER's decision will be final and binding.

It will be the CONTRACTOR'S responsibility to assist the OWNER to obtain approval from local statutory authorities including Electrical Inspector, wherever applicable, for carrying out any work and / or for installation carried out which comes under the purview of such Authorities. The scope will include submission of necessary documents duly filled in, obtaining preliminary approval of drawings, obtaining permission to start erection, arranging for visit of statutory authority after completion of erection work and obtaining permission to charge.

It is the responsibility of the CONTRACTOR to provide watch & ward and security for the equipment/component parts covered in this contract. Any loss of equipment/component parts, after take over by the CONTRACTOR, till the installation is handed over to the OWNER, shall be made good by the CONTRACTOR.

The CONTRACTOR shall be responsible for cleaning all equipment under erection, under storage, the work area and the project site at regular intervals to the satisfaction of the OWNER/ENGINEER. In case the cleaning is not to the OWNER's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the OWNER in this regard will be to the CONTRACTOR's account.

In order to avoid hazards to personnel moving around the equipment such as switchgear etc. which is kept charged after installation, before commissioning, such equipment shall be suitably cordoned off to prevent anyone accidentally going near it.

The CONTRACTOR shall carry out touch-up painting on any equipment, if the finish paint on the equipment is soiled or marred during installation/handling. The paint including primer thinner & shade of the paint to match with OWNER's specification, shall be deemed to be included in the scope of the CONTRACTOR

The CONTRACTOR shall ensure workmanship of good quality and shall assign qualified supervisors/engineers and competent labour who are skilled having valid licence/authorisation/work permit, careful and experienced in carrying out similar works. The OWNER/ENGINEER shall reserve the right to reject non-competent person employed by the CONTRACTOR, if the workmanship is not found satisfactory. Wherever required the CONTRACTOR shall include loaning of skilled/unskilled personnel for work by OWNER/other agencies, on Man-hour/Manday rates, for normal & overtime work to meet the project schedule.

It shall be the responsibility of the CONTRACTOR to obtain necessary Licence/Authorisation/permit for work for his personnel from the Licensing Board of the locality/state where the work is to be carried out. The persons deputed by the CONTRACTOR's firm should also hold valid permits issued or recognised by the Licensing Board of the locality/state where the work is to be carried out.

INSTALLATION WORK SCOPE

TEMPORARY LIGHTING ARRANGEMENT FOR THE WORK AREA

The CONTRACTOR shall on his own arrange for the temporary lighting arrangement for the work area to carry out the installation work in the plant premises.

CONSTRUCTION POWER

Construction power including power for testing and temporary lighting will be made available at one point & suitable number of outlets to cater to all the requirements shall be derived by the CONTRACTOR. All safety requirements for distribution of power like provision of protective devices for over current, earth fault, earth leakage and equipment earthing shall be considered. CONTRACTOR will be charged for the power consumed as per the rates indicated in contract. Construction power equipment is deemed to be included in the scope of installation CONTRACTOR. Only the power required for load test of the equipment will be made available to the CONTRACTOR free of cost. CONTRACTOR shall inform the requirement of construction power in kVA/ MVA to the OWNER during bidding stage/ well in advance so that same can be arranged by the OWNER prior to commencement of construction work. If it is mentioned in project specific requirements that construction power has to be arranged by CONTRACTOR then CONTRACTOR shall arrange for the same through local EB or DG sets.

The CONTRACTOR shall install, test and commission the equipment furnished by the OWNER. The quantities, approximate sizes and weights of the equipment shall be as indicated in Schedule of Prices.

Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Tolerances shall be as established in the MANUFACTURER's drawings or as stipulated by the OWNER/ENGINEER. No equipment shall be permanently bolted down to foundation or structure until the alignment has been checked and found acceptable by the OWNER/ENGINEER.

Care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish or damaging of delicate instruments or other electrical parts. Adjustment shall be made

as necessary to the stationary structures for plumb and level, for the sake of appearance or to avoid twisting of frames, binding of hinged members etc.

The CONTRACTOR shall move all equipment into the respective buildings through the regular doors or floor/wall openings provided specifically for lifting/moving the equipment. Wherever the OWNER's crane is made available for lifting heavy equipment and materials, the CONTRACTOR shall move the equipment from storage site to the crane, attach to the crane hook to the point(s) provided specifically for handling and install in final location. The CONTRACTOR shall submit time schedule to the OWNER, of the requirements for use of cranes. The CONTRACTOR shall make his own arrangement for lifting of the equipment when the OWNER's crane or cranes are not available. Operation of the OWNER's crane shall be by OWNER's personnel only. No part of the structure shall be utilised to lift or erect any equipment without prior permission of the OWNER/ ENGINEER.

Foundation work for all transformers, switchgears, motors, control panels/desks, neutral grounding equipment, cable trenches etc. will be carried out by the civil CONTRACTOR. However minor modifications to foundations, wherever found necessary for proper installation, shall be carried out by the CONTRACTOR. Base frames for switchgear/control panel when called for in Price Schedule shall be fabricated by the CONTRACTOR.

All external cabling including end connections and earthing will be carried out separately under cabling and earthing works respectively.

CONTRACTOR shall arrange for periodic inspection of the material/equipment in his custody until taken over by OWNER. CONTRACTOR shall also keep a check on the deliveries/stored equipment/material covered under his scope of erection. The CONTRACTOR shall advise OWNER well in advance regarding possible hold-up in his work due to expected delays in delivery of free issue of materials.

The CONTRACTOR shall include the following in his scope, whenever applicable.

Supply & installation of danger/warning plates, labels, insulation rubber sheets/gloves, insulation mats, first aid chart & box, sand bucket with steel stand, fire extinguishers, artificial respirator, approved single line diagram framed in glass cover etc., quantities shall be as indicated in Price Schedule.

Danger/warning plate having text written in English, Hindi and applicable vernacular language shall be provided on all electrical equipment for voltages 415V and above. The boards shall have the skull and cross bones, danger sign, together with the inscription, inscribed in white letters on red background. Electrical installation CONTRACTOR shall mount these boards at site on any of the equipment which are not provided with danger/warning plates. The danger/warning plates shall comply with the standards mentioned in Data Sheet and applicable regulations

Site fabrication of items to meet specific situations e.g. Junction boxes, wire mesh enclosures, etc. of different sizes, as called for in Price Schedule of the specification.

Chipping and punching holes/openings in concrete floors/walls and brick walls and finishing them good and providing channels and embedments wherever required.

EQUIPMENT INSTALLATION

TRANSFORMERS

Site inspection, storage, installation, testing and commissioning of transformers shall be in accordance with the specified code of practices, MANUFACTURER's instructions and the commissioning check list enclosed with the specification.

The CONTRACTOR shall (a) assemble the transformers with all fittings such as bushings, cooler banks, radiators, conservators, valves, pipings, cable boxes, marshalling boxes, OLTC, cooling fans/pumps etc. (b) arrange for oil filtration before filling, (c) Provide wedges/clamps to rigidly station all transformers on rails, (d) connect up the transformer's terminals and (e) lay and terminate the cables/conduits between all the accessories mounted on the transformer tank/cooler and the transformer marshalling kiosk.

Care shall be taken during handling of insulating oil to prevent ingress of moisture or foreign matter. In the testing, circulating, filtering or otherwise handling of oil, rubber hoses shall not be used. Circulation and filtering of oil, heating of oil by regulated short-circuit current during drying runs and sampling and testing of oil shall be in accordance with the MANUFACTURER's instructions/specified Code of Practice.

SWITCHGEARS, MCCs, PCCs, PDBs, CONTROL & RELAY PANELS

All the AC/DC Switchgears, HV/LV switchgear, MCCs, PCCs, PDBs and control and relay panels/desks, lighting distribution boards etc. shall be installed in accordance with specified Code of Practice, drawings furnished and the MANUFACTURER's instructions and respective commissioning check lists enclosed with the specification. The switchgear/panels shall be installed on finished surfaces or concrete or steel sills. These panels may be bolted on to the foundation pockets or welded to base frame members as detailed in the drawings to be furnished to the CONTRACTOR. The CONTRACTOR shall be required to install and align any channel sills which form part of the foundations. Proper aligning, joining of various vertical shipping sections, busbar connections, inter panel wiring etc. will be the responsibility of the CONTRACTOR. In joining shipping sections of the switchgear/panels/control centres together, adjacent housing or panel sections provided shall be bolted together after alignment has been completed. Power bus enclosures, ground and control splices of conventional nature shall be cleaned and bolted together, being drawn up with torque wrench of proper size or by other approved means.

The CONTRACTOR shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments and relays are supplied separately, they shall be mounted only after the associated control panels/desks have been erected and aligned. The blocking materials/mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels/desks have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the OWNER/ENGINEER.

BUSDUCT

Whenever called for, busducts (segregated/ non-segregated or isolated as the case may be) supplied by others, will have to be erected by the CONTRACTOR in accordance with specified code of practice, manufacturer's instructions and the drawings furnished by the VENDOR/OWNER. Indoor portion of the busduct may be supported from the floor or ceiling beams and outdoor portion of the busduct shall be supported from ground below on suitable foundation (which is by civil CONTRACTOR). Wall frame assembly shall also be installed as per VENDOR drawings, wherever called for.

MOTORS

Unless otherwise specified, the motors will be installed by the driven equipment VENDOR. However, the CONTRACTOR under this specification shall undertake pre-commissioning checks and testing of the motors. The installation/commissioning shall be as per the applicable code of practice, MANUFACTURER's instructions and commissioning check list for motors enclosed with the specification.

D C SYSTEM

Installation and testing of D C system i.e. Battery and battery chargers shall be carried out in strict compliance with the MANUFACTURER's instructions and commissioning check list enclosed with the specification. Each cell shall be inspected for breakage and condition of cover seals as soon as it is received at site. Each cell shall be filled with electrolyte in accordance with the MANUFACTURER's instructions. Battery shall be set up on racks as soon as possible after receipt, utilising lifting devices supplied by the MANUFACTURER. The cells shall not be lifted by the terminals. Contact surfaces of battery terminals and intercell connectors shall be cleaned, coated with acid resistant grease and assembled. Each connection shall be properly tightened. Each cell shall be tested with hydrometer and thermometer and results logged. Freshening charge, if required, shall be added. When handed over to the OWNER, the battery shall be fully charged and electrolyte shall be at full level and of specified specific gravity.

NEUTRAL GROUNDING EQUIPMENT

Bidder's Stamp & Initials

The CONTRACTOR shall install, test and commission the neutral grounding equipment (NGR, NGT etc.) as per MANUFACTURER's instructions/relevant codes and standards and commissioning check list enclosed with the specification.

MISCELLANEOUS ITEMS

Whenever applicable, communication equipment, space heater panels, local starters, capacitors and every other electrical equipment within the plant premises shall be installed, tested and commissioned as per respective equipment VENDOR's instructions, relevant code of practice and the drawings furnished by OWNER/VENDOR. Suitable brackets, angle/channel section for wall mounted equipment shall be provided by the CONTRACTOR.

TESTING AND COMMISSIONING

All checks and tests as per the MANUFACTURER's drawings/manuals, relevant code of installation and the enclosed commissioning check lists for various types of equipment e.g. transformers, circuit breakers, isolators, lightning arresters, insulators, CVTs, wave traps, CTs, VTs, reactors, motors, relays, meters etc. shall be carried out by the CONTRACTOR as part of the installation work.

The OWNER may ask for such additional tests as in his opinion are necessary to determine that the works comply with the specification, MANUFACTURER guarantees/instructions or the applicable code of installation. The CONTRACTOR shall carry out such additional tests also.

The CONTRACTOR shall perform operating/functional tests on all switchgears and panels to verify operation of switchgear/panels and correctness of the interconnections between various items of the equipment. This shall be done by applying normal AC or DC voltage to the circuits and operating the equipment for functional checks of all control circuits, e.g. closing, tripping, control interlock, supervision and alarm circuits. All connections in the switchgear shall be tested from point to point for possible ground or short-circuit.

All site connections and shortings and interpanel wiring etc. required to be carried out at site on terminals of any electrical equipment in the plant shall be carried out by the CONTRACTOR at no additional cost.

Insulation resistance tests shall be carried out by meggers of following ratings:

(a)	Control circuits up to 220V	- by 500V megger
(b)	Power circuits, busbars, connections up to 11 kV	- by 1000V megger
(c)	Power circuits, busbars connections above 11 kV & up to 33 kV	- by 2500V motor operated megger
(d)	Power circuits, busbars, connections above 33 kV	- by 5000V motor operated megger

The CONTRACTOR shall make available the following Testing and Commissioning equipment for testing and commissioning of various equipment in the plant :

- (a) 500V and 1000V hand operated meggers.
- (b) 5000V/2500V motor operated meggers.
- (c) Earth resistivity testing equipment.
- (d) Phase sequence indicators.
- (e) Frequency meters.

- (f) Micrometers
- (g) High potential testing sets suitable for testing cables up to 33 kV grade complete with transformer, rectifier stack, instruments and control.
- (h) Miscellaneous instruments/accessories like clip-on ammeters, voltmeters, wattmeters, multimeters, power factor-meters, time-interval meters, single-phase and three-phase variacs, portable transformers, switches etc.
- (i) Continuity testers.
- (j) Primary injection equipment.
- (k) Secondary injection testing kit.
- (l) Insulating oil breakdown test set with accessories.
- (m) Equipment for measuring the thermal resistivity of the soil.
- (n) Transformer oil filtration equipment.
- (o) Relay test kits.
- (p) Breaker timing device for Circuit breaker opening/closing time measurement.
- (q) CT & VT testing apparatus.
- (r) Low resistance measuring instrument.
- (s) Partial discharge measuring equipment.

The OWNER's authorised representative shall be present during every test as called for by the OWNER. The CONTRACTOR shall record all test values and furnish the required copies of the test data to the OWNER. Electrical circuits and equipment shall be energised or used at normal operating voltage only after such reports have been accepted as satisfactory by the OWNER.

SAFETY PROCEDURE

Contractor shall have safety plan and procedure complying with the relevant standards which must be followed strictly including engagement of certified safety officers/ supervisors to control and monitor safety aspects during execution of the work. They shall also follow OWNER/ ENGINEER's requirement of safety as applicable.

Contractor shall carry out safety training program regularly at site for his personnel and workmen before any execution work is taken up.

It is the responsibility of the CONTRACTOR to arrange safety shoes, helmets, safety goggles, welding protectors, safety belts, flash proof dress, grounding equipment etc as required.

1.0 APPLICABLE STANDARDS (CABLING SYSTEMS)	1.	CODE OF PRACTICE FOR FIRE SAFETY OF BLDGS.	□ IS: 1646
	2.	GUIDE FOR SAFETY PROCEDURES AND PRACTICES IN ELECTRICAL WORK	□ IS:5216
	3.	ACCESSORIES FOR RIGID STEEL CONDUITS	□ IS:3837 □ BS:4568
	4.	FITTINGS FOR RIGID STEEL CONDUITS	□ IS:14768 □ IEC:61035
	5.	FITTINGS FOR RIGID NON-METALLIC CONDUITS	□ IS:3419 □ BS:4607
	6.	ADAPTORS FOR FLEXIBLE STEEL CONDUITS	□ IS:4649 □ BS:731
	7.	CODE OF PRACTICE FOR STRUCTURAL STEEL	□ IS:800 □ BS:5950
2.0 APPLICABLE STANDARDS (LIGHTING SYSTEMS)	1.	CODE OF PRACTICE FOR ELECTRICAL WIRING INSTALLATION	□ IS:732 □ IEC/TC:64
	2.	CODE OF PRACTICE FOR INTERIOR ILLUMINATION	□ IS:3646 □ DIN:5035
	3.	CODE OF PRACTICE FOR STREET LIGHTING INSTALLATION	□ IS:1944 □ BSCP:1004 □ CIEPUB12
	4.	GUIDE FOR SELECTION OF ELECTRICAL EQUIPMENT FOR HAZARDOUS AREAS	□ IS:5571 □ IEC:60079
	5.	CODE OF PRACTICE FOR INDUSTRIAL LIGHTING	□ IS:6665 □ IES: TECH REP 2
	6.	CODE OF PRACTICE FOR FIRE SAFETY OF BLDGS.	□ IS:1646

2.0 APPLICABLE SANDARDS (LIGHTING SYSTEMS)	7.	BOXES FOR ENCLOSURES OF ELECTRICAL ACCESSORIES	□ IS:14772 □ IEC: 60670
	8.	FLAME-PROOF ENCLOSURES OF ELECTRICAL APPARATUS	□ IS/IEC:60079
	9.	GUIDE FOR SAFETY PROCEDURES AND PRACTICES IN ELECTRICAL WORK	□ IS:5216
	10.	CEILING ROSES	□ IS:371 □ BS:67
	11.	ACCESSORIES FOR RIGID STEEL CONDUITS FOR ELECTRICAL WIRING	□ IS:3837 □ BS:4568
	12.	FITTINGS FOR RIGID STEEL CONDUITS FOR ELECTRICAL WIRING	□ IS:14768 □ IEC:61035
	13.	PVC INSULATED CABLES CABLE VOLTAGES UPTO AND INCLUDING 450/750V	□ IS:694 □ IEC:60227 □ BS:6500
	14.	PVC INSULATED HEAVY DUTY ELECTRIC CABLES	□ IS:1554 □ IEC:PUB 502 □ BS:6346
3.0 APPLICABLE SANDARDS (EARTHING AND LIGHTNING PROTECTION)	1.	CODE OF PRACTICE FOR EARTHING	□ IS:3043 □ IEC:PUB 364 □ BS:84 □ IEEE:142
	2.	PROTECTION OF BUILDING AND ALLIED STRUCTURES AGAINST LIGHTNING	□ IS: □ IEC:62305
	3.	CODE OF PRACTICE FOR ELECTRICAL INSTALLATIONS	□ IS:732 □ IEC/TC:64
	4.	HOT DIP GALVANISING ON IRON AND STEEL	□ IS:2629 □ BS:729
3.0 APPLICABLE SANDARDS (EARTHING AND LIGHTNING PROTECTION SYSTEM)	5.	CODES FOR WELDING	□ IS:816 □ BS:1856 □ DIN:4100
	6.	GALVANISED ROUND STEEL WIRE	□ IS:3975
	7.	COPPER CONDUCTORS	□ IS:12444 □ BS:6360
	8.	METHODS OF TESTING UNIFORMITY OF COATING OF ZINC COATED ARTICLES	□ IS:2633 □ BS:729 □ ASTM:239

4.0 APPLICABLE STANDARDS (EQUIPMENT INSTALLATION)	1.	INSTALLATION AND MAINTENANCE OF TRANSFORMERS	☐ IS:10028
	2.	CODE OF PRACTICE FOR MAINTENANCE AND SUPERVISION OF MINERAL INSULATING OIL IN EQUIPMENT	☐ IS:1866 ☐ BS:5730 ☐ IEC:60422
	3.	INSTALLATION AND MAINTENANCE OF SWITCHGEAR	☐ IS:10118
	4.	INSTALLATION AND MAINTENANCE OF INDUCTION MOTORS	☐ IS:900
	5.	GUIDE FOR SAFETY PROCEDURES AND PRACTICES IN ELECTRICAL WORK	☐ IS:5216
	6.	HOT DIP GALVANISING	
	7.	CODES FOR WELDING	☐ IS:2629 ☐ BS:729
	8.	ELECTRICAL WIRING INSTALLATIONS VOLTAGES >650V	☐ IS:816 ☐ BS:1856 ☐ DIN:4100
	9.	FIRE SAFETY OF BUILDINGS (GENERAL) - ELECTRICAL INSTALLATIONS	☐ IS:732 ☐ IEC/TC:64 ☐ IS:1646
4.0 APPLICABLE STANDARDS (EQUIPMENT)	10.	DANGER PLATES	☐ IS:2551
	11.	NEW INSULATING OILS	☐ IS:335 ☐ IEC:60296 ☐ BS:148
	12.	INDIAN ELECTRICITY ACT 1910, (AS AMENDED)	
	13.	ELECTRICITY SUPPLY ACT 1948, (AS AMENDED)	
	14.	INDIAN ELECTRICITY RULES 1956 (AS AMENDED)	
5.0 NOTES	1	ELECTRICAL INSTALLATION WORK SHALL CONFORM TO (IF ADDITIONAL STANDARDS REQUIRED)	☐ IS: ☐ BS: ☐ IEC:

CODES AND STANDARDS

The electrical installation work shall comply with the latest applicable Standards, Regulations and Safety Codes of the locality where the installation is carried out. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the

revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

GENERAL SCOPE

The CONTRACTOR shall take over the equipment to be erected from the OWNER'S storage yard/stores/sheds/railway siding, transport the equipment's where required in actual position, erect, assemble all parts of the equipment and test and commission the same. As and when required CONTRACTOR shall have his own storage for equipment brought to site by him

The CONTRACTOR shall furnish all tools, welding equipment, rigging materials, scaffolding, platforms, ladders, testing equipment, test connections, kits, etc. required for complete installation, testing and commissioning of the items included in the contract work.

The OWNER may engage specialist engineers from the equipment MANUFACTURERS to supervise the installation, testing and commissioning of their equipment. The CONTRACTOR shall extend full co-operation to these engineers and carry out the works as per their instructions. The CONTRACTOR's work shall include minor rewiring/modifications as may be necessitated during commissioning. Providing such assistance shall be deemed to be included in the CONTRACTOR's basic scope. Whenever required the CONTRACTOR shall include loaning of skilled and unskilled personnel for work by OWNER/other agencies, on Man-hour/Man-day rates, for normal and overtime work to meet the project schedule.

The CONTRACTOR shall be co-operative through the OWNER/ENGINEER with other contractors at site, in all matters of common interest, so as not to obstruct operation of others and to ensure the safety of all personnel and works covered under this specification. In case of any conflict, OWNER's decision will be final.

It will be the CONTRACTOR'S responsibility to obtain approval/clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities.

The work shall be carried out strictly as per the instructions and layout drawings of the OWNER/ENGINEER/MANUFACTURER. In case of any doubt/misunderstanding as to correct interpretation of the drawings or instructions, necessary clarifications shall be obtained from the OWNER/ENGINEER. The CONTRACTOR shall be held responsible for any damage to the equipment consequent to not following the MANUFACTURER's instructions correctly. All necessary drawings, MANUFACTURER's equipment manuals will be furnished to the CONTRACTOR who shall return the same after completion of work.

The CONTRACTOR shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after take over by the CONTRACTOR, till the installation is taken over by OWNER shall be made good by the CONTRACTOR.

The CONTRACTOR shall have a separate cleaning gang to clean all equipment under erection as well as the work area and the project site at regular intervals as deemed fit by the OWNER/ENGINEER to the satisfaction of the OWNER/ENGINEER. In case the cleaning is not to the OWNER'S satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the OWNER in this regard will be to the CONTRACTOR's account.

In order to avoid hazards to personnel moving around the equipment such as switchgear etc., which is kept charged after installation, before commissioning, such equipment shall be suitably cordoned off to avoid accidental operation of the equipment or accidental contact with any of the Live parts.

The CONTRACTOR shall carry out touch-up painting on any equipment indicated by the OWNER/ENGINEER, if the finish paint on the equipment is soiled or marred during installation handling. The paint including primer, thinner & shade of the paint to match with OWNER's specification will be supplied by the CONTRACTOR

The CONTRACTOR shall include the following in his scope whenever applicable.

Supply and installation of danger warning plates, labels, insulation mats, fire extinguishers, first aid chart, etc.

Site fabrication of items to meet specific situations e.g. cable trays, junction boxes, wire mesh enclosures etc.

Chipping and punching holes/openings in concrete floors/walls and brick walls and finishing them good and providing channels and embedment's wherever required. Provision of chequered plates to close floor openings left around switchgears/panels etc. together with supply of materials.

The CONTRACTOR shall ensure workmanship of good quality and shall assign qualified supervisors/engineers and competent labour who is skilled, careful and experienced in carrying out similar works. The OWNER/ENGINEER shall reserve the right to reject non-competent persons employed by the CONTRACTOR, if the workmanship is not of good order.

It shall be the responsibility of the CONTRACTOR to obtain necessary Licence/Authorisation/Permit for work (before commencement of work and permission to charge) from the Licensing Boards of the Locality/State where the work is to be carried out. The persons deputed by the CONTRACTOR's firm should also hold valid permits issued or recognised by the Licensing Board of the Locality/State where the work is to be carried out.

EQUIPMENT INSTALLATION WORK

The CONTRACTOR shall arrange for the temporary lighting arrangement for the work area to carry out the installation work in the plant premises.

Construction power including power for testing and temporary lighting will be made available at one point if specifically agreed between OWNER AND CONTRACTOR . Otherwise it will be the CONTRACTORS responsibility to arrange for such power. Suitable number of outlets to cater to all the requirements shall be derived by the CONTRACTOR. Provision of necessary protective devices shall be included in scope of CONTRACTOR.

The CONTRACTOR shall install, test and commission the equipment furnished by the OWNER. The quantities, approximate sizes and weights of the equipment shall be as indicated in schedule of prices section-F.

Equipment shall be installed in a neat workmanlike manner with proper care during handling to avoid any distortion or damages to delicate instruments.

Foundation work for all equipment will be carried out by the civil contractor. However minor civil works wherever found necessary for proper installation shall be carried out by the CONTRACTOR under this specification. Base frames for switchgear/MCC/control panel when called for in section F shall be fabricated by the CONTRACTOR.

Care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish or damaging of delicate instruments or other electrical parts. Adjustment shall be made as necessary to the stationary structures for plumb and level, for the sake of appearance or to avoid twisting of frames, binding of hinged members etc.

The CONTRACTOR shall move all equipment into the respective buildings through the regular doors or floor/wall openings provided specifically for lifting/moving the equipment. Wherever the OWNER's crane is made available for lifting heavy equipment and materials, the CONTRACTOR shall move the equipment from storage site to the crane, attach to the crane hook to the point(s) provided specifically for handling and install in final location. The CONTRACTOR shall submit time schedule to the OWNER, of the requirements for use of cranes. The CONTRACTOR shall make his own arrangement for lifting of the equipment when the OWNER's crane or cranes are not available. Operation of the OWNER's crane shall be by OWNER's personnel only and it will be made available to the erection contractor on chargeable basis for their scope of work. No part of the structure shall be utilised to lift or erect any equipment without prior permission of the OWNER/ ENGINEER.

CONTRACTOR shall arrange for periodic inspection of the material/equipment in his custody until taken over by OWNER. CONTRACTOR shall also keep a check on the deliveries/stored
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equipment/material covered under his scope of erection. The CONTRACTOR shall advise OWNER well in advance regarding possible hold-up in his work due to expected delays in delivery of free issue of materials.

Installation, testing and commissioning of all equipment shall be in accordance with the specified codes of practice and Manufacturer's instructions and respective commissioning check lists enclosed with this specification.

Transformers

As and when applicable, CONTRACTOR shall (a) assemble the transformer with all the fittings such as radiators, bushings, cooler banks, conservator, valves, piping's, marshalling boxes etc. (b) arrange for oil filtration before oil filling (c) providing wedges/clamps for rigidly stationing transformers on rail (d) connect up the transformer's terminals (e) lay and terminate the OWNER's cables.

Due care shall be taken by CONTRACTOR to avoid any ingress of moisture or foreign matter during handling of insulation oil.

When lifting a transformer by the lifting lugs or shackles provided for the purpose, simultaneous use should be made of all such lugs and shackles in order to avoid any unbalance while lifting. The lifting chain should never interfere, with any part of the transformer. Before lifting complete transformer, it should be ensured that all cover bolts are tightened fully. In case where it is necessary to use jacks for lifting, jacking shall not be under valve or cooling tubes. For transporting transformers from stores to site, the transformers shall be loaded on a suitable capacity truck or trailer. The transformers shall be properly supported by steel ropes and stoppers on the trailer to avoid tilting of the transformers in transit due to jerks and vibrations. At no instance a transformer shall be kept on bare ground. Where it is not possible to unload the transformer directly on a foundation, these shall be unloaded on a properly built wooden sleeper platform. A transformer shall never be left without putting stoppers to the wheels.

Except large power transformers, all the lighting and small distribution transformers shall be placed on the prepared concrete bed. Large power transformers shall be placed after grouting channels or rails, over concrete foundations. The transformers shall be levelled, aligned and checked for free movement on the rails. Stoppers shall be clamped to the transformers immediately to prevent any movement. All the accessories where supplied loose, like radiators, cooling fans, valves, conservator tanks, explosion-vent pipe, bushings and other devices should be cleaned and tested before fixing on the transformer. All the connections for C.T.s, bushings and other wiring shall be checked for tightness and correctness before replacing the lid or tightening all the bolts.

For LT Dry type transformer, the CONTRACTOR shall transport the transformers from store/railway siding to site and place them on their foundations, assemble different parts and accessories, fabricate and erect all the supporting structures for detachable cable boxes, complete all conduit erection and wiring connections.

Where assemblies are supplied in more than one section/package, CONTRACTOR shall make all necessary mechanical and electrical connections. All insulators and bushings shall be protected against any damage due to negligence or carelessness of CONTRACTOR during installation. Insulators/Bushings, chipped/cracked due to negligence or carelessness of the CONTRACTOR shall be replaced by CONTRACTOR at his own expense.

Switchgear, Control/Relay Panels

The switchgear shall be handled with care, avoiding impact to the equipment; by the skilled manpower under the guidance of a competent supervisor. Dragging of the panels shall be avoided and use of a crane and trailer shall be made for the handling purposes while transporting to various sites. The switchboard shall be properly supported on the truck or trailer by means of ropes to avoid any chances of damage or tilting due to heavy vibration. The switchboards should be lifted by making use of lifting eyebolts only, fully tightened after ensuring that panel supports, nuts and bolts are all intact and tightened. When panels are to be lifted in packed conditions, utmost care shall be taken to avoid any damage to insulators, bushings, metering and protective equipment. The panels shall preferably be kept inside the packing cases till foundations are ready.

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Base channels shall be grouted, levelled, in cement concrete pad for low voltage switchgear panels and other cubicle panels. A level benchmark shall be given by the OWNER as reference level, and further all levels shall be checked and kept with theodolite by the CONTRACTOR. Pedestal type panels and MCCs shall be erected by grouting base channels by bolts. A proper bonding surface should be made by chipping the floor while making cement concreting. All foundations, grouted bolts shall be cured for a minimum period of 48 hours.

The switchboard panels should be taken out from the packed cases and moved one by one to the proper place. All the panels should be assembled, aligned, levelled and it should be ensured that panel to panel coupling bolts, bus bar links fit properly without any strain on any part. It should also be checked up that lowering, lifting, racking in and out operation of the breaker and all other motions are free from any obstruction. The fixing bolts should be grouted only after satisfying all these requirements. The panels shall be checked for correct vertical position using pendulum weight and spirit levels. L.T. switchgear panels can be tack welded at suitable intervals for each shipping section.

After completion of the panel erection, all the cubicles switches, starters, C.T. and P.T. chambers, bus bars chamber should be cleaned and checked for tightness of all the components. All loosely supplied items shall be fitted up. All the wiring connections should also be checked with drawings and tightened. Metering and protective C.Ts, alarm, indications and protective relays should be fitted up. Phase sequence & polarity of

PTs and CTs should be checked. Contact resistance of all bus bar joints and contactors should be checked up. Every part or insulator should be checked for any possible damage. All the starters, switches, contacts should be cleaned with C.T.C. Silver tipped contacts should be checked for easy and free movement. Hinges of panel doors should be lightly lubricated to give free and noiseless movement. All openings shall be kept completely closed to avoid ingress of any foreign particles inside the panel.

Switchgear and control/relay panels/desks shall be installed on finished surfaces or concrete or steel sills. Proper aligning, joining of various vertical shipping sections, bus bar connections, inter panel wiring etc. will be the responsibility of CONTRACTOR.

The CONTRACTOR shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments and relays are supplied separately, they shall be installed only after erection of switchgear/relay panels is complete.

Bus ducts

If specified in scope of work, bus ducts supplied by others will have to be erected by the CONTRACTOR. The CONTRACTOR shall provide suitable support structure for bus ducts. Indoor portion of the bus duct may be supported from the floor or ceiling beams and outdoor portion of the bus duct shall be supported from ground below on suitable foundation (foundation by civil CONTRACTOR). Wherever called for, the wall frame assembly shall also be made good as per bus duct Vendor drawings.

The bus duct will be supplied in parts and all the parts shall be assembled and the bus bar connections shall be made at site. The insulator in bus ducts shall be inspected for any possible damage during transit and the defective ones shall be replaced. The insulators shall be cleaned with carbon tetrachloride. Contact surface of bus bars, bus-bar bolts and nuts shall be thoroughly cleaned with petrol and wiped. Petroleum jelly shall then be applied and bolted connection made. The bus duct enclosure shall be checked for earth continuity and then earthed at two places. The bus duct shall be duly supported between switchgear and transformer. The opening in the wall where the bus duct enters the switchgear room shall be completely sealed to avoid rainwater entry. Expansion joints, flexible connections, wall frame assembly, seal off bushings etc. supplied by the manufacturer of the bus duct shall be properly connected. The bus duct levelling shall be checked with spirit level and pendulum weight. Location of flexible joints shall be marked for identification.

Motors

Unless otherwise specified all the motors will be installed by other agencies. However, pre-commissioning checks and testing of the motors will be by the CONTRACTOR.

Insulation resistance of the motors shall be measured between the winding of the machine and its frame by means of a 500/1000V megger in case of LT motors. A minimum value of 1 mega-ohm for 415V motors shall be considered a safe value.

Insulation resistance of MV motors shall be by 2500V megger and its value shall not be less than 20 mega-ohms at 60 deg. C

Battery and Chargers

Battery shall be set up on the racks. Contact surfaces of battery terminals and inter cell connectors shall be cleaned and coated with protective grease and assembled. Each cell shall be inspected for breakage and condition of cover seals as soon as it is received at site. Each cell shall be filled with electrolyte in accordance with the MANUFACTURER's instructions. The cells shall not be lifted by the terminals. Each cell shall be tested with hydrometer and thermometer and results logged. Freshening charge, if required, shall be added. The battery shall be fully charged and electrolyte shall be at full level and of specified specific gravity at the time of handing over to the OWNER.

Welding Receptacles

The welding receptacles shall be erected on steel structures/concrete as per the drawings. In isolated places a separate support shall be fabricated and installed.

Erection of welding receptacle shall be done by fixing the socket with screws using rawl plug or by anchor fasteners. IR/HV test values shall be taken. Interlocks if any and switch operation shall be checked. Power cable shall be terminated properly and the receptacles shall be grounded at two separate points.

240/24V Transformer and Flame proof sockets (24V)

The 240/24V transformers shall be an integral part of 24V flameproof hand lamp socket. Necessary supporting structures shall be fabricated out of mild steel and the same shall be painted. Only galvanized steel bolts, nuts & washers shall be used. Power cable shall be properly terminated and switch operation and mechanical/electrical interlock shall be checked.

Socket shall be properly grounded.

Miscellaneous Items

Communication equipment, space heater and ventilation distribution boards, local starters, capacitors, exhaust fans with starters and with louvers assembly and any other electrical equipment within the plant premises shall be installed, tested and commissioned as per respective VENDOR's instructions and the drawings furnished by OWNER.

Suitable brackets, angle/channel section for support of wall mounted equipment shall be provided by the CONTRACTOR

CABLING SYSTEM INSTALLATION WORK

Scope of Supply:

Following items as required shall be supplied by the CONTRACTOR. Required types and quantities shall be as specified in schedule of prices,

Galvanised steel cable trays (ladder and perforated types), cable tray covers and vertical raceway covers.

Cable glands, lugs and trefoil clamps.

GI rigid and flexible conduits/pipes

Cable termination kits.

Miscellaneous items like junction boxes/marshalling boxes, push button stations, power receptacles, space heater and ventilation distribution boards.

Mounting / supporting structure for cable trays

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Cable Trays and Accessories

The cable trays shall be complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be hot dip galvanised.

Cable Glands & Lugs

Cable glands shall be of robust construction and of double compression type. Cable lugs shall be of tinned copper, solder less crimping type suitable for aluminium or copper conductors.

Conduits and Pipes

The CONTRACTOR shall supply galvanised steel/coated conduits, GS pipes and flexible conduits as required for the cabling work. Conduits shall be seamed by welding and shall be hot dip galvanised both inside and outside. Pipes shall be of heavy duty type and hot dip galvanised both inside and outside. Flexible conduits shall be made with bright, cold rolled, annealed and galvanised mild steel strips.

Power Receptacles

The power receptacles shall be industrial heavy duty type with switches for 3-phase, AC supply with 3 pin and earth connections. The receptacles shall have ratings of 32 Amps and 63 Amps. The socket and switch shall have suitable interlock facility for safety. The receptacles shall be provided with matching plugs. Each unit shall be complete with gasket, cable glands, cable lugs and earthing terminals with washers and nuts.

Junction Boxes/Marshalling Boxes

Junction boxes/marshalling boxes shall be hot-dip galvanised, weather proof with IP 55 degree of protection. The terminals shall be suitable for terminating 2 numbers 2.5 mm² conductors on each side. All terminal blocks shall be rated for 1100V, 15A unless otherwise specified. All the terminals shall be complete with insulated barriers, terminal studs, washers, nuts, etc.

Local Push Button Stations

The local push button/control stations shall be installed near the motors to be controlled. Individual channel supports shall be used for each of the push button stations. These shall be installed as per approved erection detail drawing. Control station for hazardous areas shall be certified and approved by regulatory authorities.

The local push button stations shall be metal enclosed, weather-proof, dust and vermin proof, suitable for mounting on wall or steel structures. The enclosure shall be die cast aluminium or sheet steel of 2 mm thickness and provide a degree of protection of not less than IP: 55. The enclosure shall be painted with one coat of epoxy primer and two coats of light grey epoxy paint.

The open/close/start push buttons shall be of momentary contact push to actuate type and stop push buttons shall be stay put type with mushroom knob. The stop push button shall be of lockable type in 'OFF' position. All push buttons shall be fitted with two (2) normally open and two (2) normally closed contacts rated for 415V, 10A.

The following types of push button stations shall be supplied.

Type-A: With three push buttons for control of reversible motors.

Type-B: With two push buttons for control of non-reversible motors.

Type-C: With one push button for 'stop' operation.

Space heater and Ventilation Distribution Boards

Space heater/ventilation distribution boards shall be sheet steel enclosed indoor, dust and vermin proof and wall mounting type. The enclosure shall be of 2.0 mm thick cold rolled sheet steel and provide degree of protection of not less than IP: 52. All doors, removable covers and plates shall be with neoprene gaskets all around. The boards shall be complete with cable

glands, lugs, removable gland plates, two nos. earthing terminals and other necessary accessories.

The space heater boards and ventilation distribution boards shall have one (1) No. 3-phase incoming feeder. The space heater board shall have specified no. of single phase outgoing feeders whereas ventilation distribution boards shall have both 3 phase as well as single phase outgoing feeders as specified in section-C.

Wherever 4 wire supply is not available, 4 wire supply shall be derived using 415/ 433 Volts transformers. Distribution boards with transformers shall be suitable for floor mounting. The transformers shall be of dry type and shall have the following technical parameters (unless otherwise specified in Section-C).

(a)	KVA rating	:	100 KVA/50 KVA
(b)	Voltage rating	:	415/433 V
(c)	P.U. Impedance	:	5%
(d)	Off circuit taps	:	± 2.5 %
(e)	Vector group	:	DYn1

Scope of installation work

The cabling system installation work shall include unloading, storing, installation, fixing, jointing/termination, testing and commissioning of complete cabling system items and any other work/items necessary for completing the job.

Major civil works are excluded from the scope of this specification. These include construction of cable trenches, cable tunnels, duct banks etc. Normally the required embedment plates will be provided by others at the time of civil construction. Wherever the embedment plates are not provided by others, the ELECTRICAL CONTRACTOR shall provide the embedment plates by using anchor fasteners. However, minor civil works such as making holes/grooves in floor slab/wall and patching up in an approved

manner any holes made in the walls/floors by the CONTRACTOR, embedment of short lengths of conduits, plates in floors, walls etc. if not already done by Civil Contractor shall be deemed to be included in the scope of ELECTRICAL CONTRACTOR.

Following are the itemised scope of cabling installation work.

Cable laying and installation

The CONTRACTOR shall install, test and commission power and control cables which will be furnished by the PURCHASER. The quantities, sizes and types of cables shall be as indicated in SOR.

The cables shall be laid in built-up trenches, directly buried in ground, on cable trays, vertical raceways, clamped on structures/walls/ceiling, pulled through pipes and conduits etc. as shown in the typical/project drawings. Unit rates quoted for installation of cables shall be same irrespective of route and method of laying. The scope of cable installation shall include laying, pulling of cables, proper dressing of cables on cable trays, racks, vertical raceways and supply and installation of saddles, spacers and nylon cord for tying as required.

The cost of excavation & back filling and supplying brick covers for medium and low voltage cables and pre cast concrete covers/half round RCC pipe covers for high voltage cables, route/joint markers, supply of sand shall be included in the rate of directly buried cables on cubic metre basis.

Cable Termination

All cables shall be connected at both ends. The CONTRACTOR shall quote unit prices for termination of cable at one end, for each type/size of cable. The scope of work shall include making the requisite holes in the gland plate, fixing the glands, terminating the cables in the glands, mounting of core balance CT if required, earthing the cable armour, crimping the cable lugs on each core, neatly clamping the cables in cable alleys/wiring troughs and connecting to the terminals. The cable and core identification tags shall be supplied and installed by the CONTRACTOR.

Cable termination for HT cables shall be generally as described in (a) above and shall include heat shrinkable tubing system of cable termination.

Cost of supplying cable glands, cable lugs, and cable termination kits shall be included under unit rates for cable termination.

Cable Tray and Tray Covers Installation

Installation details for cable trays shall be as shown in 'Cabling Notes and Details'. All cable racks, vertical raceways and supporting steel shall be installed at the locations shown in the various layout drawings. The sizes of ladder/perforated cable trays to be supplied and installed shall be 150, 300, 450, 600 and 750 mm wide.

The rate quoted for installation shall include all hardware, welding materials, touch-up paint and other consumables. No separate rates shall be admissible for accessories like elbows, tees, reducers, etc. These shall be included in the straight run measurements. However, the cable tray installation rates shall not include the rates for steel supports which are covered under a separate item.

The CONTRACTOR shall also include earthing of the cable trays at distance not exceeding 10Mtrs. length by means of G.S. Flat. The size of the GS flat shall be as shown in project drawings.

Installation rates shall be same for horizontal or vertical run/disposition of cable trays. Unit rates for dismantling cable trays/steel work shall be same as that for installation unless defined separately in BOQ/PO, if the case arises. Prices for installation of site fabricated trays shall be same as that of pre-fabricated trays.

All vertical raceways/trays and outdoor trays (topmost layer) shall be covered by 16 gauge painted/galvanised MS sheet covers. For outdoor applications whenever the cables are directly exposed to Sun rays, they shall be provided with sun shields to protect the cables from direct heating by Sun rays. The estimated lengths and widths of these covers are indicated in BOQ. The scope of work shall include the installation of these covers including necessary screws when required for fixing to vertical raceways/trays.

Cable Trays/Vertical Raceways Mounting Arrangements and Cable Carrier Structures

The CONTRACTOR shall fabricate, install and paint the following as per relevant enclosed drawings/general notes:

Mounting arrangements for cable trays. Any cable trays junction bends which are non-standard shall be fabricated as racks to suit installation drawings.

Vertical cable raceways and steel accessories (angles and plates) required to seal the floor openings in the case of indoor raceways.

Cable carrier structures (racks) for cable trenches and tunnels.

Supporting steel for junction/marshalling boxes, push-button stations, vertical structures for clamping trefoil cables, etc., as required.

The steel members shall be welded to the floor beams, columns, plates embedded in R.C. floors or grouted in brick walls as the case may be to obtain the required supporting arrangements as detailed in relevant drawings. The cable racks and supports shall be painted after installation with one coat of red lead primer, one coat of oil primer followed by two coats of aluminium paint.

The above mounting structures/cable racks shall be fabricated from standard structural steel members (channels, plates, angles and flats) as indicated in enclosed project drawings. The estimated quantity of steel are furnished in section-F and the rate for the same shall be quoted separately on per tonne basis. The unit rates quoted for installation shall include fabrication of support, erection, welding, grouting, painting including supply and installation of all hardware to make the installation complete in all respects.

Conduits/Pipes Installation

The CONTRACTOR shall install all conduits/pipes required for the cabling work as per enclosed project drawings/notes. The sizes and quantities shall be as indicated in BOQ.

Conduits/pipes shall be laid buried in ground, laid along the walls/structural members, along floors and ceilings. Conduit and pipe sleeves which are required to be embedded in walls, roof slabs, floors, trench and tunnel walls, under roads and tracks etc. will in

general be furnished in place wherever necessary by the PURCHASER for the portion of civil work completed until the time, the CONTRACTOR for cabling work reaches site. However, in places where such pipe sleeves have not been provided by the PURCHASER, the CONTRACTOR shall install conduit/pipe sleeves in place wherever necessary by breaking walls/floors as required by the ENGINEER to PURCHASER's satisfaction. All conduits/pipes shall have their ends closed by caps until cables are pulled.

Water-proof sealing shall be done for all outdoor to indoor conduit/pipe inserts by means of bell mouth termination pieces and bitumen based cold set water-proof compound. Fire-proof sealing shall be done for pipe inserts in floor slabs, in walls of pressurised rooms and hazardous area, wherever indicated in project drawings. The water-proof/fire-proof sealing of pipe inserts shall be as per the typical drawings enclosed. The supply and installation rates of the necessary water-proof/fire-proof sealing compounds shall be separately indicated by the CONTRACTOR if asked for in BOQ

The scope of installation of conduits/pipes shall include supply and installation of all accessories like tees, elbows, pull-boxes, conduit end plugs, bell-mouths, GI wire for cable pulling, GI saddles, spacers, screws, nuts and bolts. The scope for directly buried pipes/conduits shall include excavation and back filling as per varying depths/widths mentioned in project drawings. The CONTRACTOR shall indicate this scope on per cubic metre basis if asked for in BOQ

Cable Joints

Jointing of cables shall be made in accordance with relevant codes of practice and MANUFACTURER's special instructions. Cables shall be firmly clamped and supported within 300 mm from the joint to avoid mechanical stresses on the joint.

Joints shall not be permitted in control cables. However, in long runs of power cables, joints shall be permitted at an accessible location which shall be chosen in consultation with PURCHASER/ENGINEER before work is taken up. A record of all joints giving cable number, type of cable, type of joint, location and date of jointing shall be kept by the CONTRACTOR.

Jointing kits shall be suitable for the type of cable and for underground buried installation. The CONTRACTOR shall offer

Heat shrinkable jointing kits/cast resin type or tapex type jointing kits, complete with insulating materials, stress grading/relieving materials, plastic mould, resin, tinned copper lugs, plumbing materials and all other accessories to make the joint complete in all respects. Unit rates for supply and jointing shall be furnished for each type and size of cable if asked for in Section F. Unit rate quoted for outdoor straight through Joints/Jointing kits shall include erection of temporary shelter and safeguarding against ingress of moisture.

A 5M loop of cable shall be kept at each joint

Cable Trays and Markers

Each cable shall be tagged with numbers that appear in the cable schedule. The tag shall be of aluminium with the number punched on it and securely attached to the cable/conduit by not Bidder's Stamp & Initials

less than two turns of 20 SWG GI wire. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables. Cable tags shall be provided on all cables at each end, on both sides of wall/floor crossings, on each duct/conduit entry and at every 8 to 10 metres in cable trench/tray racks.

Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 20 meters, and at every change in direction. They shall be located on both sides of road and drain crossings.

The price of cable tags and markers shall be included in the installation rates for cables/conduits.

Sealing of Floor Openings

All floor openings for vertical cable trays/raceways shall be sealed by fire-proof compound. The scope of work shall include preparing and laying of the compound. The supply and installation rate for the compound shall be indicated separately by the CONTRACTOR if asked for in BOQ .

EARTHING AND LIGHTNING PROTECTION SYSTEM INSTALLATION

Scope of Supply

The earthing and lightning conductors, electrodes and accessories shall be supplied by the CONTRACTOR as mentioned in the relevant project layout drawings and schedule of prices BOQ .

The material, type and size shall be as indicated in the schedule of prices section-F.

When steel earthing conductors are specified, the same shall be hot dip galvanised when laid above ground unless otherwise stated to prevent atmospheric corrosion. Earthing conductor laid below ground shall be circular M.S conductor or as specified in section F.

When copper earthing conductors are specified, the same shall be stranded and annealed soft drawn type. Copper earthing rods and flats shall be hard drawn type. If specified in section-C, lead coating shall be provided on copper conductors to prevent its corrosion in aggressive environments.

Scope of Installation Work

The installation work shall include unloading, storing, laying, fixing, jointing/terminations, testing and commissioning of the safety earthing system of the plant and lightning protection system for buildings and allied structures. All welding/brazing equipment, necessary tools and testing equipment shall be furnished by the CONTRACTOR. Installation work shall also meet the requirements stipulated in Earthing and Lightning protection System Installation Notes:.

The CONTRACTOR shall carry out the lightning protection and earthing of all equipment/panels/structures as indicated in the PURCHASER's drawings. Whether specifically shown in drawings or not, building columns, hand rails, miscellaneous items such as junction/marshalling boxes, field switches, cable boxes etc., shall be earthed.

The CONTRACTOR shall install bare/insulated, copper/aluminium/steel conductors, braids, etc., required for system and individual equipment earthing. All work such as cutting, bending, supporting, painting/coating, drilling, brazing/soldering/welding, clamping, bolting and connection onto structures, equipment frames, terminals, rails or other devices shall be in the CONTRACTOR's scope of work. All incidental hardware and consumables such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts, washers, bitumen compound, anti-corrosive paint as required for the complete work shall be deemed to be included by the CONTRACTOR as part of the installation work.

The approximate quantities, sizes and material of earthing conductors and electrodes to be installed shall be as indicated in schedule of prices BOQ and routes of the conductors and locations of electrodes shall be shown on the project drawings. The layout of conductors shown in the earthing drawings is approximate and these may be suitably shifted / finalised

in consultation with the site ENGINEER/OWNER to avoid any interference. If earth connection to any device is not shown specifically in the relevant earthing drawings, it shall be field routed.

The work of embedment of earthing conductor in RCC floors/walls along with provision of earth plate inserts/pads/earth risers shall normally be done by the civil contractor when the floors/walls are cast. However, when required to do so in these areas where flooring is to be done after the ELECTRICAL CONTRACTOR is at site, the ELECTRICAL CONTRACTOR shall co-ordinate with civil contractor and shall install the earthing conductors before the commencement of concrete work. In such cases, the CONTRACTOR's scope of installation shall include laying the conductors in position (before civil contractor makes 50 mm concrete finish flooring) making welded/brazed/cad weld joints as required including the requisite plate inserts/pads/risers above the floor near the equipment. The embedded conductors shall be connected to reinforcing rods wherever necessary.

The tap connections (earthing leads) from the floor embedded main earthing grid to the equipment of more than 500 mm long shall be embedded in floor by the CONTRACTOR where required, together with associated civil work such as excavation/chasing, concreting and surfacing, if not already done by the civil contractor. The concrete cover over the conductor shall not be less than 50 mm.

The installation of earth conductors in outdoor areas, buried in ground shall include excavation of trenches in earth (600 mm deep and 450 mm wide unless otherwise stated in project drawings), laying of conductor at 600 mm depth (unless stated otherwise), brazing/welding/cad welding as required, of main grid conductor joints as well as risers above ground at required locations and backfilling of trenches. Backfilling material to be placed over buried conductor shall be free from stones and other harmful mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the ditch, and tampered utilising pneumatic tampers or other approved means. If the excavated soil is found unsuitable for backfilling, the CONTRACTOR shall arrange for suitable soil from outside.

The installation of earth connection leads to equipment and risers on steel structures/walls shall include laying the conductors, welding/cleating at specified intervals, welding/brazing to the main earth grid's risers, bolting at equipment terminals and coating welded/brazed joints by bitumastic paint. Galvanized conductors shall be touched up with zinc rich paint where holes are drilled at site for bolting to equipment/structure.

The scope of installation of electrodes shall include installation of electrodes (a) directly in earth, (b) in constructed earth pits and connecting to main buried earth grid, as per enclosed project drawings/relevant standards. The scope of work shall include excavation, construction of the earth pits including all materials required for construction of the earth pits, placing the rod, providing and fixing test links on those electrodes in test pits and connecting to main earth grid conductors.

The scope of installation of lightning conductors on the roofs of buildings shall include providing concrete upstands on roof, laying, fastening and cleating of horizontal conductors, grouting of vertical rods where necessary, laying fastening/cleating/welding of the down comers onto the walls/columns of the building and connection to the test links above ground level.

The installation of the test links shall include mounting of the same at specified height on wall/column by suitable brackets and connections of the test link to the earth electrode.

LIGHTING SYSTEM INSTALLATION WORK

The lighting system installation work shall cover the supply of lighting system equipment such as lighting distribution boards (LDBs), lighting panels (LPs), receptacles, light control switches, ceiling fans, lighting wires, conduits, junction boxes, lighting poles, towers, etc. if called for in scope and as described in enclosed standard and installation of these equipment along with lighting fixtures with lamps and accessories to be given by OWNER.

The CONTRACTOR shall carry out the installation of various lighting equipment as indicated in the PURCHASER's layout drawings. The work shall include unloading, storing, unpacking, fixing of all equipment, routing and laying of conduits/cables, wiring, termination, testing and commissioning of all the equipment of lighting system.

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The supply of all mounting accessories, earthing wires and incidental hardware and consumable like fixing saddles, spacer plates, junction boxes and conduits required for the fitting fixing/suspension points, joint boxes and connectors, jointing, ferrules, all fixing brackets, screws and studs, shall be deemed to be included as part of installation work. Mounting accessories like saddles, spacer plates, joint boxes, junction boxes and fixing hardware shall be of galvanised mild steel/black enamelled steel.

The installation of lighting fixtures shall be based on the mounting arrangement shown in the drawings/BOQ. The unit rates quoted for installation of lighting fixtures shall include all materials required to mount the fixtures and control gear boxes wherever applicable.

Unit rates for installation of ceiling fans shall be based on mounting with standard suspension length of 300 mm unless noted elsewhere. Supply and installation of necessary hooks and regulator in switch box shall be included in the unit rate for installation of ceiling fans.

The CONTRACTOR shall work in coordination with the Civil and Air-conditioning Contractors and where holes or openings in walls and floors, cut-outs in false ceilings are required the CONTRACTOR shall inform the ENGINEER and other respective Contractors. Holes in wall made by the CONTRACTOR shall necessarily be patched-up by him in a good and approved manner, using the same kind of masonry as in the uncut surfaces.

The CONTRACTOR shall carry out touch-up painting on lighting panels/boards if the same is damaged during installation handling.

Point Wiring

Wiring of lighting fixtures/receptacle units/ceiling fans with regulators shall be on point wiring basis. Two types of point wiring have been envisaged viz. primary point wiring and secondary point wiring. CONTRACTOR shall quote primary point and secondary point wiring rates for each of building/area specified, on the basis of lighting layout drawings enclosed with the specification. Point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches and regulators of ceiling fans/control switches of receptacle units.

Primary Point Wiring

Primary point wiring covers the wiring between a circuit of the lighting panel to the first lighting fixture/ceiling fan/receptacle unit, connected to that circuit of the lighting panel. In some cases where there are junction boxes, the primary point covers the wiring between junction box and the first lighting fixture/ceiling fan/receptacle unit in that circuit.

Secondary Point Wiring

Secondary point wiring covers the wiring of the remaining lighting fixtures/ceiling fans/receptacle units other than that covered under primary point of that circuit in the lighting panel.

Option of a combined point wiring item, including primary and secondary wiring can also be considered instead of separate rates

Cabling for Street and Boundary Lighting

The cabling for street and boundary lighting can be executed BOQ item based or point wiring based. In case of point wiring based the details shall be as below:

Primary Point Wiring

Primary point wiring covers the wiring between the lighting distribution board/lighting panel to the junction box of the first lighting pole or flood light tower and between the junction boxes of the subsequent lighting poles or flood light towers connected to a circuit in the lighting distribution board/lighting panel.

Secondary Point Wiring

Secondary point wiring covers the wiring between the junction box and the lighting fixture on the pole in case of street light and between junction box mounted near the base of the tower

and all subsequent junction boxes mounted on that tower and also between junction box and the flood light fixture. The above refers to the remaining fixtures covered under the circuit referred under primary point wiring. Secondary point also covers the wiring of the associated control fuses, switches, looping of terminals, etc. as required.

In case it is BOQ based, all the applicable items with quantity from the description mentioned above shall be listed separately and executed accordingly

Supply and Installation of Conduit Point Wiring

The point wiring shall include supply of necessary materials for the conduit wiring such as coated/galvanised rigid steel conduit/black enamelled M.S. conduit, HR PVC heavy duty conduit (for residential building projects), galvanised M.S. fixing saddles with spacer plates, nylon/fibre fixing plugs, galvanised M.S. fixing screws, 14 SWG galvanised steel earthing wire, FR PVC insulated copper conductor wires, control switches and pulling, termination of the earthing/PVC insulated wire as required, installation of control switches, drilling holes in brick walls/RCC roof slabs for taking the wiring conduits and refinishing and any other works/material necessary for making point wiring complete in all respects.

Minimum size of conduit shall be 20 mm/25 mm for exposed/concealed conduits respectively.

Wires used for conduit point wiring of lighting fixtures/ceiling fans and receptacles shall be 1100V grade, FR PVC insulated, single core, multistranded copper conductor wires of sizes not less than 1.5 sq.mm and 2.5 sq.mm respectively for commercial and Residential or as specified in BOQ. Wires shall conform to IS standards and shall bear the ISI mark.

Wherever concealed conduit wiring is required the supply and installation of rigid conduits in ceiling/walls from lighting panels to lighting fixtures/receptacles, inspection/junction boxes etc. shall be in CONTRACTOR's scope. The CONTRACTOR shall closely coordinate his work with that of the civil contractor.

Supply and Installation of Cable Point Wiring

The cable point wiring shall include supply of necessary materials for the cable wiring such as 1100V grade, multicore, stranded aluminium/copper conductor, PVC insulated, armoured cables of sizes 2.5 sq.mm/4 sq.mm/6 sq.mm, for wiring of fixtures and receptacles in buildings where cable wiring is specified, MS fixing saddles with spacing plates, junction boxes, nylon/fibre fixing plugs, galvanised MS fixing screws, control switches and installation/termination of cables including supply of cable glands as required, installation of control switches, junction boxes, drilling holes in brick walls/RCC roof and grouting necessary conduit sleeves for taking the cables and any other work/materials necessary for making the point wiring complete in all respects.

Supply & Installation of Point Wiring for Street and Flood Lighting-

The cabling for street and flood lighting can be executed BOQ item based or point wiring based. In case of point wiring based the details shall be as below:

Supply and installation of cables required between LDB/LP and junction box mounted on street lighting pole/flood lighting tower and also between junction box to metal enclosed control gear box and fixtures, supply and installation of all the termination accessories such as crimping type cable lugs and cable glands at each junction box and fixture, termination, testing and commissioning of cables. CONTRACTOR's scope of work also includes excavation, preparation of riddled soil bedding, supply and installation of protective covers over the cable, backfilling, ramming, supply and installation of route markers, supply and installation of hume pipes for road crossing, supply and installation of necessary cleating arrangement for cables on flood light tower, etc.

Earthing of street light pole/flood light tower, lighting fixtures, control gear boxes, junction boxes, etc. are also included in the scope of point wiring. Earth strip of size as per project requirement shall be run along with the street lighting/flood lighting cable and looped from pole to pole. The earth strip from the end pole shall be connected to the nearby available grid. If nearby earth grid is not available, last lighting pole shall be earthed by providing local untreated earth pit with rod electrode near the lighting pole. The cost of supply and installation of earthing conductor/rod shall be included in the cost of point wiring for outdoor lighting.

Alternatively, instead of running the earth strip along with the cable local untreated earth pit with rod electrode shall be provided for a group of @ 5 poles.

In case it is BOQ based, all the applicable items with quantity from the description mentioned above shall be listed separately and executed accordingly

CONTRACTOR shall provide necessary foundation for erecting street light pole/flood light tower/high mast and install the same. CONTRACTOR shall furnish foundation drawings with necessary details to PURCHASER/CONSULTANT for approval.

Fixture locations are liable to be shifted marginally at site within a radius of 3 to 4 meters from what is shown in the layout drawings. Point wiring rates quoted by the CONTRACTOR shall hold good and no extra prices shall be admissible.

Hazardous Area Wiring

The method of wiring used in hazardous area i.e. either in screwed rigid heavy gauge steel conduits or by armoured cable, shall be continued up to a distance as indicated below from the boundaries of the demarcated area considered as hazardous:

Where processes or operations necessitating the use of flameproof equipment and fittings are carried out in open: - 6m horizontally in any direction from the boundary line and 3m vertically above the highest source of hazard.

Where processes or operations necessitating use of flameproof equipment and fittings are carried out in enclosed equipment: - Up to 6m horizontally of open face or door opening of such equipment and 3m vertically above the roof of such equipment.

Circuits in hazardous area shall be controlled by switches outside the hazardous area in a convenient place and effectively protected from weather. The switches shall disconnect from all sources of supply all unearthed conductors terminating in any outlet in the room.

Joint/junction boxes shall be avoided in hazardous area. If necessary, boxes of approved flameproof design shall be used.

Bakelite ceiling roses and switches shall not be used in hazardous areas.

ESTING AND COMMISSIONING

Electrical Equipment

All checks and tests shall be conducted as per the MANUFACTURER's drawings/manuals, relevant codes of installation and enclosed commissioning check lists.

The CONTRACTOR shall also carry out additional tests if called for in section-C of the specification.

The CONTRACTOR shall carry out insulation resistance tests by megger of following rating.

(a)	Control circuits up to 220 V	- 500 V megger
b)	Power circuits up to 433 V	- 1000 V megger
(c)	Power circuits above 433 V to 33 KV	- 2500 V megger (motorised)
(d)	Power circuits above 33 KV	- 5000 V megger (motorised)

Earthing and Lightning Protection System

The CONTRACTOR shall ensure the continuity of all conductors and joints. Earth continuity and earth resistance measurement tests shall be performed by the CONTRACTOR at places indicated by the OWNER, at no additional cost.

Test Records

The OWNER's authorised representative shall be present during every test as called for by the OWNER. The CONTRACTOR shall record all test values and furnish the required copies of the test data to the OWNER. Electrical circuits and equipment shall be energised or used at nominal operating voltage after such reports are accepted as satisfactory by the OWNER

16. SOLAR SYSTEM WORKS

The scope of services covers the design, detailed engineering, preparation of construction drawing, manufacture, acceptance testing at manufacturer's works or at any accredited agency, supply, packing, forwarding and delivery from manufacturer's works/ place of storage to erection site including transit insurance, unloading, storage at site, moving from place of storage to place of installation, assembly, erection, testing, commissioning & performance demonstration and handing over along with all necessary spares of original ratings & specifications on Design & Build basis for roof top solar PV system. Inland and overseas transit insurance, transport, testing at site shall be Contractor scope. Tender Bill of Quantities (BOQ) and Drawings are for reference purpose only which is the minimum requirements. Contractor to ensure that design & equipment are as per specification requirements.

The Contractor shall prepare design calculations based on parameters/ design criteria indicated in the specifications. The Contractor shall prepare detailed engineering and construction purpose drawings to make his/ her own estimate of ratings & quantities (minimum requirements as per price schedule, technical data sheets, reference drawings & other relevant details) for entire electrical systems including all items, systems such as equipment, cables/ cabling system, , earthing, lightning protection, power distribution, instruments, civil works required for completion of Works.

Contractor shall take due care of the site Seismic conditions while design of all equipment/ components used in entire electrical systems covered in this specification. Contractor shall furnish list of additional design parameters considered in design to fulfill above requirement.

Design and detailed engineering of the materials procured by Contractor is included in scope. Contractor shall submit design drawings/ calculations of each system which is included in scope to Purchaser/ Purchaser's representative for final review/ approval. All design documents/ calculations prepared by Contractor shall be as per ISO documentation i.e., with duly signed by qualified authorities and stamped. Design documents/ calculations prepared by Sub-Contractors shall be approved by Contractor and stamped copy of approval along with no-deviation sheet from Sub-Contractor shall be submitted by the Contractor to Purchaser/ Purchaser's representative for final review/ approval.

Expert or manufacturer supervision for SUB-Contractor supplied material shall be provided by Contractor.

Nothing in this specification shall be constructed to relieve the Contractor of his/ her responsibilities towards following best engineering practices established in the country.

Even if all components of a system included in this specification are not explicitly identified and/ or listed herein, these shall be supplied under this contract to ensure completeness of the solar PV system and facilitate proper operation and easy maintenance. Any and all other works not indicated above but necessary/ required to complete the system in all aspects, are included in the Contractor's scope.

Contractor's scope shall include design, engineering, manufacture, supply, testing, commissioning and handover of following electrical equipment/ systems as per tender specifications, BOQ, reference drawings and other relevant details for the scope of work.

Solar PV Panels along with mounting accessories, module mounting structure, Inverters, surge protectors for AC & DC, DC cables, LT AC Cables, junction boxes, connectors/combiners, ladder & perforated cable trays, LT Panel complete with all required accessories.

Net metering, Data Logging & Monitoring System and Provision for continuous monitoring of electrical Power & Energy parameters like Voltage, Current, Power Factor, Frequency, Kilo Watts, Kilowatt-Hours as per MNRE requirement etc.

Earthing for equipment and lightning protection system for all solar installation in the plant premises. The general design shall be on the basis of following codes and standards (their latest amendments) in line with design criteria & specification requirements.

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a)	IS 3043	:	Code of practice for Safety Earthing
b)	IS/ IEC 62305	:	Code of Practice for the protection of buildings and allied structures against lightning.
c)	CEA guidelines 2010	:	Measures related to safety & electric supply.

GENERAL TECHNICAL & PARTICULAR REQUIREMENTS FOR ELECTRICAL EQUIPMENT/ SYSTEMS:

DEFINITION

A Grid Tied Solar Rooftop Photo Voltaic (SRPV) power plant consists of SRPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), Inverter, and Controls & Protections, interconnect cables, Junction boxes, Distribution boxes and switches. PV Array is mounted on a suitable structure. Grid tied SRPV system is without battery and should be designed with necessary features to supplement the grid power during day time. Components and parts used in the SRPV power plants including the PV modules, metallic structures, cables, junction box, switches, PCUs etc., should conform to the BIS or IEC or international specifications, wherever such specifications are available and applicable. Solar PV system shall consist of following equipment/components.

- Solar PV modules consisting of required number of Mono Crystalline PV cells.
- Surge Protectors
- Cables DC & AC LT Cables.
- Cable Trays
- Grid interactive Power Conditioning Unit
- Mounting structures
- Junction Boxes.
- AC Distribution Panel Boards
- Earthing and lightening protections.
- IR/UV protected PVC Cables, Conduits and accessories

SOLAR PHOTOVOLTAIC MODULES:

The PV modules used should be made in India.

The PV modules used must qualify to the latest edition of IEC PV module qualification test or equivalent BIS standards Crystalline Silicon Solar Cell Modules IEC 61215/IS14286. In addition, the modules must conform to IEC 61730 Part-1 - requirements for construction & Part 2 – requirements for testing, for safety qualification or equivalent IS.

For the PV modules to be used in a highly corrosive atmosphere throughout their lifetime, they must qualify to IEC 61701.

The total solar PV array capacity should not be less than allocated capacity (kWp) and should comprise of solar crystalline modules of minimum 154 Wp and above wattage.

Protective devices against surges at the PV module shall be provided. Low voltage drop bypass diodes shall be provided.

PV modules must be tested and approved by one of IEC authorized test centers preferable NABL accredited.

The module frame shall be made of corrosion resistant materials, preferably/ shall be anodized aluminum.

Efficiency of PV modules at standard test conditions (STC) shall not be less than 15.5% and fill factor of the module shall not be less than 0.80.

Modules shall be made of light weight cells, resistant to abrasion, hail impact, rain, water and environmental pollution. The PV modules shall be provided with anti-reflection coating

Other general requirement for the PV modules and subsystems shall be as follows:

- The rated output power of any supplied module shall have tolerance within +/-3%.
- The peak-power point voltage and the peak-power point current of any supplied module and/or any module string (series connected modules) shall not vary by more than 2 (two) per cent from the respective arithmetic means for all modules and/or for all module strings, as the case may be.
- The module shall be provided with a junction box with either provision of external screw terminal connection or sealed type and with arrangement for provision of by-pass diode. The box shall have hinged, weather proof lid with captive screws and cable gland entry points or may be of sealed type and IP-65 rated.

I-V curves at STC should be provided by bidder.

Modules deployed must use a RF identification tag. The following information must be mentioned in the RFID used on each module. This should be inside the laminate only.

- Name of the manufacturer of the PV module
- Name of the manufacturer of Solar Cells.
- Month & year of the manufacture (separate for solar cells and modules)
- Country of origin (separately for solar cells and module)
- I-V curve for the module Wattage, I_m, V_m and FF for the module
- Unique Serial No and Model No of the module
- Date and year of obtaining IEC PV module qualification certificate.
- Name of the test lab issuing IEC certificate.
- Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001

Power Conditioners/ Inverters including MPPT and Protections: Efficiency Measurements as per IEC 61683 / IS 61683(10%, 25%, 50%, 75% & 90-100% Loading Conditions) and Environmental Testing as per IEC 60068-2 (1, 2,14, 30) / Equivalent BIS Std. Safety of power converters for use in photovoltaic power systems shall be as per IEC 62109-1, IEC 62109-2. Overall efficiency of grid-connected photovoltaic inverters shall be as per BS EN 50530/IEC 62891. Utility-interconnected Photovoltaic Inverters - Test Procedure of Islanding Prevention Measures as per IEC 62116 or, IEEE 1547.

Switches/Circuit Breakers /Connectors: General Requirements Connectors –safety A.C./D.C. as per IEC 60947 part I,II, III / IS 60947 Part I,II,III EN 50521.

Junction Boxes /Enclosures for Inverters/Charge Controllers: General Requirements Junction boxes and solar panel terminal boxes shall be of the thermo plastic type with IP 65 protection for outdoor use, and IP 54 protection for indoor use as per IEC 60529.

Meters: a.c. Static direct connected watt-hour Smart Meter Class 1 and 2 — Specification (with Import & Export/Net energy measurements) As per IS 16444/ latest CEA Guidelines/ DISCOM guidelines.

Solar PV Roof Mounting Structures: Material for the structure mounting as per IS 2062/IS 4759. In-addition, "IS 800: Code of practice for general construction in steel" shall be followed, along-with the 'National Building Code' (latest edition)

Surge Arrestors: Low-voltage surge protective devices - Part 11: Surge protective devices connected to low voltage power systems - Requirements and test method as per IEC 61643-11:2011 / IS 15086-5 (SPD).

Lightning Protection System Components: Lightning protection system components (LPSC) - Part 1: Requirements for connection components shall be as per IEC 62561 Series (Chemical earthing) or, equivalent Indian Standards

Earthing: S.I.T.C. of earth pit of minimum bore dia 150 mm size aproved make Safe Earthing Electrode consisting pipe-in pipe Technology made of corrosion free GI Pipe having outer pipe dia of 50 mm having 80-200 Micron galvanising, Inner pipe dia of 25 mm having 200-250 Micron galvanising connection terminal dia. of 12 mm with constant ohmic value surrounded by highly conductive compound with high charge dissipation suitable for following type of applications. independent earthing in normal soil with Length of Pipe 3.00 mtr. & Back filling compound - 2 No. Bag of 25Kg each. Separate double earthing for solar mounting structure, inverters and lighting arrester.

In each location where solar trees are provided, net metering with a separate LT panel with adequate nos. of incoming from Solar trees and an outgoing for the existing supply. The existing meter shall be replaced by net meter and the supply to existing Panel shall be taken from the newly installed LT panel, so that there will not be any requirement of augmentation in the existing power system.

The structure/ pylon/trunk shall be not less than 4m high from the ground level.

The Design Wind-load bearing capacity shall be as per IS 875 Part 3.

Single axis Tracking system with controller with Fully Automated East to West Tracking

Inbuilt panel washing system.

Warranties:

Material Warranty:

- Material Warranty is defined as: The manufacturer should warrant the Solar Module(s) to be free from the defects and/or failures specified below for a period not less than five (05) years from the date of sale to the original customer ("Customer")
- Defects and/or failures due to manufacturing
- Defects and/or failures due to quality of materials
- Non conformity to specifications due to faulty manufacturing and/or inspection processes. If the solar Module(s) fails to conform to this warranty, the manufacturer will repair or replace the solar module(s), at the Owners sole option

Performance Warranty:

The predicted electrical degradation of power generated not exceeding 20% of the minimum rated power over the 25 year period and not more than 10% after ten years period of the full rated original output.

CIVIL FOUNDATIONS AND ARRAY STRUCTURE

The structures shall resist the worst combination of the required/ specified loads / stresses under test and working conditions; these include dead load, live load, equipment load, water pressure, soil pressure, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, dynamic loads.

Hot dip galvanized MS mounting structures shall be used for mounting the modules/ panels/arrays. Each structure should have angle of inclination as per the site conditions to take maximum insulation. However to accommodate more capacity the angle inclination may be reduced until the plant meets the specified performance ratio requirements.

The Mounting structure shall be so designed to withstand the speed for the wind zone of the location where a PV system is proposed to be installed (Bangalore-wind speed of 33m/s as per IS 875 Part 3). Bidder may design the structures to sustain wind speed as specified in the indicated IS code. It may be ensured that the design has been certified by a recognized Lab/ Institution in this regard and submit wind loading calculation sheet to Consultant for approval. Suitable fastening arrangement should be provided to secure the installation against the specific wind speed.

The structures shall be designed taking into considerations the Seismic zone (earthquake loading) for the region. This shall be computed as per I.S. 1893. The site falls in Zone II as per IS: 1893 (2002). An importance factor appropriate to the type of structure shall be considered for design of all the structures. Environmental condition shall be considered appropriate as per IS 456, IS 800.

The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion as applicable. Permissible stresses for different load combinations shall be taken as per latest IS456.

The mounting structure steel shall be as per latest IS 2062: 2011 and galvanization of the mounting structure shall be in compliance of latest IS 4759.

As far as possible non penetrative methods shall be preferred for mounting the structures over conventional penetrative method for the foundations for all kinds of roofs – GI sheet as well as RCC roofs tops.

Structural material shall be corrosion resistant and electrolytic ally compatible with the materials used in the module frame, its fasteners, and nuts and bolts. Aluminum structures also can be used which can withstand the wind speed of respective wind zone. Necessary protection towards rusting need to be provided either by coating or anodization.

The fasteners used should be made up of stainless steel. The structures shall be designed to allow easy replacement of any module. The array structure shall be so designed that it will occupy minimum space without sacrificing the output from the SRPV panels

Regarding civil structures the bidder need to take care of the load bearing capacity of the roof and need arrange suitable structures based on the quality of roof.

The total load of the structure (when installed with PV modules) on the terrace should be less than 75 kg/m².

The minimum clearance of the structure from the roof level should be 300 mm.

JUNCTION BOXES (JBs)

The junction boxes are to be provided in the PV array for termination of connecting cables. The JB's shall be made of Polycarbonate/GRP/FRP/Powder Coated Aluminum /cast aluminum alloy with full dust, water & vermin proof arrangement.

It should be UV resistant in accordance with suitable for outdoor application at an ambient of 50°C.

The junction boxes shall have IP protection of IP 65 for outdoor and IP21 for Indoor as per IEC 529.

All wires/cables must be terminated through cable lugs. The JB's shall be such that input & output termination can be made through suitable cable glands.

Copper bus bars/terminal blocks housed in the junction box with suitable termination threads Conforming to IEC 62208 Hinged door with EPDM rubber gasket to prevent water entry. Double compression cable glands. Provision of earthing. It should be placed at 5 feet height or above for ease of accessibility.

All the component including the Hardware that are required for mounting shall be include in the scope of work.

Each Junction Box shall have High quality Suitable capacity Metal Oxide Varistors (MOVs) / SPDs, suitable Reverse Blocking Diodes. The Junction Boxes shall have suitable arrangement for disconnection of each of the groups.

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Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.

The fuses shall be provided on both positive and negative terminal of the incoming string.

All fuses (Input Side) shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP 65 enclosures with transparent covers.

Array Junction Box shall have isolator that will be used to disconnect both positive and negative sides simultaneously on output side.

Array Junction Box shall have the sensors to monitor below parameters

- Analog signals: 1. String currents 2. String Voltage
- Digital signals: 1. Isolator ON/OFF status

There shall be provision for mounting RTD element on String Monitoring device

Either shunt-based (or) CT/hall-effect sensor (LEM)-based Mechanism shall be employed for sensing string currents together with Analog to digital converters for converting above current, voltage and temperature signals.

Monitoring of the following parameter shall be possible using SCADA

- DC Switch ON/OFF Status
- SPD operated
- Ambient and Junction box Temperature
- Bus Voltage
- Current through individual string
- Overall Output Current

Insulated pin type and ring type lugs, ferrules, cable ties etc. required for connecting the communication cables to the combiner boxes shall be in the bidder scope.

Routine tests shall be conducted, as per relevant standards (IS, IEC etc), shall be carried out on the string combiner box and all the tests may be witnessed by Client/ Client representatives. Vendor shall submit manufacturing quality plan, indicating relevant IS/IEC standards for Client's approval. Following shall be the minimum checks

- Visual inspection check
- Bill of materials check
- Electrical continuity check
- HV insulation tests
- Functional checks

Test reports shall be submitted prior to dispatch of the system to the site.

Type test report for Temperature rise test performed at NABL accredited Lab shall be submitted for approval for Client/ Client's representative.

PCU/ARRAY SIZE RATIO:

The combined wattage of all inverters should not be less than rated capacity of power plant under STC.

Maximum power point tracker shall be integrated in the PCU/inverter to maximize energy drawn from the array.

PCU / Inverter:

As SPV array produce direct current electricity, it is necessary to convert this direct current into alternating current and adjust the voltage levels to match the grid voltage. Conversion shall be achieved using an electronic Inverter and the associated control and protection

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devices. All these components of the system are termed the “Power Conditioning Unit (PCU)”. In addition,

PCU shall also house MPPT (Maximum Power Point Tracker), an interface between Solar PV array & the Inverter, to the power conditioning unit/inverter should also be DG set interactive, if necessary. Inverter output should be compatible with the grid frequency. Typical technical features of the inverter shall be as follows:

Switching devices	IGBT/MOSFET
Control	Microprocessor /DSP
Nominal AC output voltage and Frequency	415V, 3 Phase, 50Hz (In case single phase inverters are offered, suitable arrangement for balancing the phases must be made.)
Output frequency	50 Hz
Grid Frequency Synchronization range	+ 3 Hz or more
Ambient temperature considered	-20o C to 50o C
Humidity	95 % Non-condensing
Protection of Enclosure	IP-20(Minimum) for indoor. IP-65(Minimum) for outdoor.
Grid Frequency Tolerance range	+ 3 or more
Grid Voltage tolerance	-0.20.15
No-load losses	Less than 1% of rated power
Inverter efficiency(minimum)	>93% (In case of 10 kW or above with in-built galvanic isolation) >97% (In case of 10 KW or above without in-built galvanic isolation)
THD	< 3%
PF	> 0.9
Surge Protection	Required on both AC as well as DC side
Enclosure	Shall be made of non corrosive material

PCU/inverter shall be capable of complete automatic operation including wake-up, synchronization & shutdown.

The output power factor of PCU inverter is suitable for all voltage ranges or sink of reactive power; inverter should have internal protection arrangement against any sustainable fault in feeder line and against the lightning on feeder.

Built-in meter and data logger to monitor plant performance through external computer shall be provided. It shall have multi-line display to indicate following parameters

- Output Voltage
- Output Current
- Output frequency
- Harmonics
- Power Factor

- KW (Output)
- kWH (Output)
- DC Input Voltage
- DC Input Current
- KW (input)
- kWH (input)

The inverter control system shall be fully compatible for remote operation via communication link.

Bidder to indicate the type of communication protocol supported by the system along with the details of links provided in the system. The control system shall operate on windows or equivalent platform.

Alarm shall be produce for the following operating conditions

- Inverter failure
- IGBT/MOSFET over temperature
- Breaker / Dis-connecter failure
- Over load
- Over load shutdown
- Emergency shutdown
- DC circuit breaker/switch open
- AC Main failure
- Fan failure
- Asynchronous condition and Synchronous condition
- Control power failure
- DC ground fault

The communication protocol in inverter shall be compatible with the Data acquisition system implemented for the entire solar plant.

Anti-islanding (Protection against Islanding of grid): The PCU shall have anti-islanding protection in conformity to IEEE 1547/UL 1741/ IEC 62116 or equivalent BIS standard.

Successful Bidders shall be responsible for galvanic isolation of solar roof top power plant with electrical grid or LT panel.

In PCU/Inverter, there shall be a direct current isolation provided at the output by means of a suitable isolating transformer. If Isolation Transformer is not incorporated with PCU/Inverter, there shall be a separate Isolation Transformer of suitable rating provided at the output side of PCU/PCU units for capacity.

The PCU/ inverter generated harmonics, flicker, DC injection limits, Voltage Range, Frequency Range and Anti-Islanding measures at the point of connection to the utility services should follow the latest CEA (Technical Standards for Connectivity Distribution Generation Resources) Guidelines and shall also be within the specified limits in IEEE 519.

Power conditioning units / inverters should comply with applicable IEC / equivalent BIS standard for efficiency measurements and environmental tests as per standard codes IEC 61683/IS 61683 and IEC 60068-2 (1,2,14,30)/ Equivalent BIS Std.

The MPPT units environmental testing should qualify IEC 60068-2 (1, 2, 14, 30)/ Equivalent BIS std. The junction boxes/ enclosures should be IP 65 (for outdoor) / IP 54 (indoor) and as per IEC 529 specifications.

The PCU/ inverters should be tested from the MNRE approved test centers/ NABL/ BIS/ IEC accredited testing- calibration laboratories. In case of imported power conditioning units, these should be approved by accredited international test houses. Bidder shall furnish copies of all type test reports required.

The Inverter shall have the option of Positive or Negative grounding. The inverter shall have less power consumption when in service and shall have minimum power consumption on standby mode. Inverter DC input side shall be provided with DC Circuit breaker and output side provided with AC circuit breaker

The minimum following devices shall be provided to protect the inverter:

- Reverse polarity
- Reverse power
- Short Circuit
- Over-current
- Earth fault protection
- Islanding
- Under / Overvoltage
- Over / Under frequency
- Surge Protection on both AC and DC side.

The BIDDER shall clearly bring out the earthing philosophy to be adopted for the Inverter electronics, protective earthing (PE) and neutral earthing. The requirement of separate earth pit independent of the plant electrical system earth pits shall be clearly brought out.

Types including Heat run test and routine tests certificates for all components used in the inverter system shall be furnished. Testing of components shall be as per relevant standards.

Bidder shall furnish copies of all type test reports required as per the relevant standards. The type test should have been carried out in last five years on equipment of similar rating. Without the type test reports, the Contract shall be considered incomplete.

Bidder shall furnish his quality assurance plan for the equipment offered. The quality assurance plan shall include bought out component and assemblies used in the Inverter system.

System tests shall be performed on the completely assembled inverter system. System tests shall include frequency regulations. Voltage regulation, current limiting feature and harmonic content tests in addition to the tests to prove the functional requirements such as synchronization with range of adjustments, overload and under voltage conditions.

Heat run test shall be carried out on inverter system at rated load under relevant ambient conditions for a period of 8 hours. This test shall be conducted as a routine test on all inverters being supplied.

INTEGRATION OF PV POWER WITH GRID:

The output produced from the SRPV System shall be supplied to the grid through inverter and proper switching arrangement. In case of power failure, or low or high voltage, solar PV system shall be out of synchronization and shall be isolated from the network.

The bidirectional electronic energy meter (0.5 S classes) shall be installed for the measurement of import/export of energy. The Meter shall be as per DISCOM norms.

The bidder must intimate to the Concerned DISCOM for the connectivity, technical feasibility, and synchronization of SRPV plant with distribution network and submit the same to GANDHINAGAR SMART CITY DEVELOPMENT LIMITED before commissioning of SRPV plant.

The Reverse power relay shall be provided by bidder (if necessary), as per the local DISCOM requirement.

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DATA ACQUISITION SYSTEM / PLANT MONITORING

Data Acquisition System shall be provided for each of the solar PV plant. The details shall be integrated with building BMS system.

Data Logging Provision for plant control and monitoring, time and date stamped system data logs for analysis with the high quality, suitable PC. Metering and Instrumentation for display of systems parameters and status indication to be provided.

Solar Irradiance: An integrating Pyranometer / Solar cell based irradiation sensor (along with calibration certificate) provided, with the sensor mounted in the plane of the array. Readout integrated with data logging system.

Temperature: Temperature probes for recording the Solar panel temperature and/or ambient temperature to be provided complete with readouts integrated with the data logging system

The following parameters are accessible via the operating interface display in real time separately for solar power plant:

- AC Voltage.
- AC Output current.
- Output Power
- Power factor.
- DC Input Voltage.
- DC Input Current.
- Time Active.
- Time disabled.
- Time Idle.
- Power produced
- Protective function limits (Viz-AC Over voltage, AC Under voltage, Over frequency, Under frequency ground fault, PV starting voltage, PV stopping voltage.
- Parameters mentioned in above Clause.

All major parameters available on the digital bus and logging facility for energy auditing through the internal microprocessor and read on the digital front panel at any time) and logging facility (the current values, previous values for up to a month and the average values) should be made available for energy auditing through the internal microprocessor and should be read on the digital front panel.

PV array energy production: Digital Energy Meters to log the actual value of AC/ DC voltage, Current & Energy generated by the PV system provided. Energy meter along with CT/PT should be of 0.5 accuracy class.

Computerized DC String/Array monitoring and AC output monitoring shall be provided as part of the inverter and/or string/array combiner box or separately.

String and array DC Voltage, Current and Power, Inverter AC output voltage and current (All 3 phases and lines), AC power (Active, Reactive and Apparent), Power Factor and AC energy (All 3 phases and cumulative) and frequency shall be monitored.

Computerized AC energy monitoring shall be in addition to the digital AC energy meter.

The data shall be recorded in a common work sheet chronologically date wise. The data file shall be MS Excel compatible. The data shall be represented in both tabular and graphical form.

All instantaneous data shall be shown on the computer screen. It shall show the mimic diagram indicating status of each system component and value of each system parameters

Software shall be provided for USB download and analysis of DC and AC parametric data for individual plant.

Provision for instantaneous Internet monitoring and download of historical data shall be also incorporated.

Remote Server and Software for centralized Internet monitoring system shall be also provided for download and analysis of cumulative data of all the plants and the data of the solar radiation and temperature monitoring system.

Ambient / Solar PV module back surface temperature shall be also monitored on continuous basis.

Simultaneous monitoring of DC and AC electrical voltage, current, power, energy and other data of the plant for correlation with solar and environment data shall be provided.

Remote Monitoring and data acquisition through Remote Monitoring System software at the owner location with latest software/hardware configuration and service connectivity for online / real time data monitoring / control complete to be supplied and operation and maintenance / control to be ensured by the bidder.

The bidders shall be obligated to push real-time plant monitoring data on a specified intervals (say 15 minute) through open protocol at receiver location (cloud server) in XML/JSON format, preferably. Suitable provision in this regard will be intimated to the successful bidder.

All the Alarm as indicated in the Clause 21.9 shall be displayed on the computer screen.

PROTECTIONS

The system should be provided with all necessary protections like earthing, Lightning, and grid islanding as follows:

LIGHTNING PROTECTION

The SRPV power plants shall be provided with lightning & overvoltage protection. The main aim in this protection shall be to reduce the over voltage to a tolerable value before it reaches the PV or other sub system components. The source of over voltage can be lightning, atmosphere disturbances etc. The entire space occupying the SRPV array shall be suitably protected against Lightning by deploying required number of Lightning Arrestors. Lightning protection should be provided as per IEC 62305 standards. The protection against induced high-voltages shall be provided by the use of metal oxide varistors (MOVs) and suitable earthing such that induced transients find an alternate route to earth. Radio-active air-terminals shall not be allowed. Any other kind of air- terminal like dissipation system shall not be acceptable.

SURGE PROTECTION

Internal surge protection shall consist of three MOV type surge-arrestors connected from +ve and –ve terminals to earth (via Y arrangement).

EARTHING PROTECTION

Each array structure of the PV yard should be grounded/ earthed properly as per IS: 3043-1987. In addition the lightning arrester/masts should also be earthed inside the array field. PCU, ACDB and DCDB should also be earthed properly.

Earth resistance shall not be more than 5 ohms. It shall be ensured that all the earthing points are bonded together to make them at the same potential.

Earthing of data logging & monitoring system shall be as per the supplier.

All other earth pits Earth electrodes shall be of heavy duty galvanized mild steel of not less than 40 mm NB and minimum 3000 mm long. Where multiple rods are used they shall be separated by a distance of not less than 2000mm.

The earth pits may require boring & drilling in the soil & the same shall be considered in Contractor's scope.

Lightning protection down comers shall not be used as earthing conductors above ground.

Earth resistance shall not be more than 5 ohms. It shall be ensured that all the earthing points are bonded together to make them at the same potential.

GRID ISLANDING:

In the event of a power failure on the electric grid, it is required that any independent power-producing inverters attached to the grid turn off in a short period of time. This prevents the DC-to-AC inverters from continuing to feed power into small sections of the grid, known as "Islands." Powered Islands present a risk to workers who may expect the area to be unpowered, and they may also damage grid-tied equipment. The Rooftop PV system shall be equipped with islanding protection. In addition to disconnection from the grid (due to islanding protection) disconnection due to under and over voltage conditions shall also be provided.

A manual disconnect 4-pole isolation switch beside automatic disconnection to grid would have to be provided at utility end to isolate the grid connection by the utility personnel to carry out any maintenance. This switch shall be provided with locking facility to be locked by the utility personnel for taking outage clearances.

CABLES

Cables of appropriate size to be used in the system shall have the following characteristics:

- Shall meet IEC 60227/IS 694, IEC 60502/IS1554 standards
- Temp. Range: –10 deg C to +80 deg C.
- Voltage rating 660/1000V
- Excellent resistance to heat, cold, water, oil, abrasion, UV radiation
- Flexible

Sizes of cables between array interconnections, array to junction boxes, junction boxes to Inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system shall not exceed 2%.

For the DC cabling, XLPE or, XLPO insulated and sheathed, UV-stabilized single core multi-stranded flexible copper cables shall be used; Multi-core cables shall not be used.

For the AC cabling, PVC or, XLPE insulated and PVC sheathed single or, multi-core multi-stranded flexible copper cables shall be used; Outdoor AC cables shall have a UV-stabilized outer sheath.

The cables (as per IS) should be insulated with a special grade PVC compound formulated for outdoor use. Outer sheath of cables shall be electron beam cross-linked XLPO type and black in color.

The DC cables module array shall run through a UV-stabilized PVC conduit pipe of adequate diameter with a minimum wall thickness of 1.5mm.

Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors (MC4) and couplers

All cables and conduit pipes shall be clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50 cm; the minimum DC cable size shall be 4.0 mm² copper; the minimum AC cable Size shall be 4.0 mm² copper.

In three phase systems, the size of the neutral wire size shall be equal to the size of the phase wires.

Cable Routing/ Marking: All cable/wires are to be routed in a GI cable tray and suitably tagged and marked with proper manner by good quality ferule or by other means so that the cable easily identified. In addition, cable drum no. / Batch no. to be embossed/ printed at every one meter.

Cable Jacket should also be electron beam cross-linked XLPO, flame retardant, UV resistant and black in color.

All cables and connectors for use for installation of solar field must be of solar grade which can withstand harsh environment conditions including High temperatures, UV radiation, rain, humidity, dirt, salt, burial and attack by moss and microbes for 25 years and voltages as per latest IEC standards. DC cables used from solar modules to array junction box shall be solar grade copper (Cu) with XLPO insulation and rated for 1.1kV as per relevant standards only.

Bidder shall indicate size and length as per system design requirement. All the cables required for the plant shall be provided by the bidder. All cable schedules/ layout drawings shall be approved prior to installation.

Multi Strand, Annealed high conductivity copper conductor PVC type 'A' pressure extruded insulation or XLPE insulation. Overall PVC/XLPE insulation for UV protection Armored cable for underground laying. All cable trays including covers to be provided. All cables conform to latest edition of IEC/ equivalent BIS Standards as specified below: BoS item / component Standard Description Standard Number Cables General Test and Measuring Methods, PVC/XLPE insulated cables for working Voltage up to and including 1100 V, UV resistant for outdoor installation IS /IEC 69947.

The total voltage drop on the cable segments from the solar PV modules to the solar grid inverter shall not exceed 2.0%.

The total voltage drop on the cable segments from the solar grid inverter to the building distribution board shall not exceed 2.0%.

CONNECTIVITY

The PV system of each Building shall be connected to the Grid at 415V at the OWNER's LT system at Main Distribution Board/ Power Control Centre (PCC) of the respective building with incoming switchgear.

DANGER BOARDS AND SIGNAGES:

Danger boards of appropriate voltage level shall be provided as and where necessary as per CEA guidelines 2010 as amended up to date. Appropriate Signage shall be provided at appropriate locations to identify the equipment, indicate the purpose etc.

FIRE EXTINGUISHERS:

The firefighting system for proposed power plant for fire protection shall be consisting of:

Portable fire extinguishers (CO2) in the control room for fire caused by electrical short circuits

Sand buckets in the control room – One stand with 4 Buckets

The installation of Fire Extinguishers should confirm to TAC regulations and BIS standards. The fire extinguishers shall be provided in the control room housing PCUs as well as on the Roof where the PV arrays have been installed.

DRAWINGS & MANUALS:

Two sets of Engineering, electrical drawings and Installation and O&M manuals are to be supplied. Bidders shall provide complete technical data sheets for each equipment giving details of the specifications along with make/makes in their bid along with basic design of the power plant and power evacuation, synchronization along with protection equipment.

Approved ISI and reputed makes for equipment offered/ to be used.

PLANNING AND DESIGNING:

The bidder should carry out Shadow Analysis at the site and accordingly design strings & arrays layout considering optimal usage of space, material and labour. The bidder should submit the array layout drawings along with Shadow Analysis Report to consultant for approval.

DRAWINGS TO BE FURNISHED BY BIDDER AFTER AWARD OF CONTRACT

The Bidder shall furnish the following drawings and obtain approval

- General arrangement of PV Panels and other equipment with dimensions and section layouts indicating all views for each location wherever Bidder's equipment shall be installed.
- Schematic drawing showing the requirement of SV panel, Power conditioning Unit(s)/ inverter, Junction Boxes, AC and DC Distribution Boards, meters etc.
- Detailed Single line Diagram (SLD) indicating the Rating of components including switchgear, bus-bar, CT, PT, cables etc.; Configuration of components; Protection details; interlocks; indications & annunciations provided; etc. for each system.
- Supporting calculations with formulae, reference to standards and assumptions shall be submitted for each system.
- Structural drawing along with foundation details for the structure.
- Itemized bill of material for complete SV plant covering all the components and associated accessories.
- Layouts of solar Power Array, cable tray routing, earthing including downcomers, lightning arrestors and earth pits with building dimensions, inverters, lighting, metering etc.
- Shadow analysis of the roof
- Type Test certificates of the components from Accredited Laboratories.

SOLAR PV SYSTEM ON THE ROOFTOP FOR MEETING THE ANNUAL ENERGY REQUIREMENT

The Solar PV system on the rooftop of the selected buildings will be installed for meeting up to 40% or as specified by the state Electricity Regulatory Commission (AERC), of the annual energy requirements depending upon the area of rooftop available and the remaining energy requirement of the office buildings will be met by drawing power from grid at commercial tariff of DISCOMs

SAFETY MEASURES:

The bidder shall take entire responsibility for electrical safety of the installation(s) including connectivity with the grid and follow all the safety rules and regulations applicable as per Electricity Act, 2003 and CEA guidelines etc.

Since the Job involves Working at Height more than 3 m, all safety measures related to Working at height shall be followed as per standard engineering practice including mounting of Pipe Scaffolding, Safety Net, Personal protective equipment, Safety Belt, Special vehicle mounted elevator etc.

Also for Maintenance purpose on regular basis working of Gujarat type Roofs, adequate foolproof safe arrangements shall be provided for the operator and workmen to carry out their routine work without and risk of accident.

Refer Safety Guidelines enclosed with this document for further requirements.

A write up of the steps to be followed and equipment to be used for installation, testing, operation and maintenance shall be provided as a part of evaluation document.

DISPLAY BOARD

The bidder has to display a board at the project site mentioning the following:

Plant Name, Capacity, Location, Type of Renewable Energy plant (Like solar, wind etc.), and Date of commissioning, details of tie-up with transmission and distribution companies, Power generation and Export FY wise.

Quality Certification, Standards and Testing for Grid-connected Rooftop Solar PV Systems/Power Plants

Quality certification and standards for grid-connected rooftop solar PV systems are essential for the successful mass-scale implementation of this technology. It is also imperative to put

in place an efficient and rigorous monitoring mechanism, adherence to these standards. Hence, all components of grid-connected rooftop solar PV system/ plant must conform to the relevant standards and certifications given below:

IEC 61215/ IS	Design Qualification and Type Approval for Crystalline Silicon
14286/IEC61646	Terrestrial Photovoltaic (PV) Modules
IEC 61701/IS 61701	Salt Mist Corrosion Testing of Photovoltaic (PV) Modules
IEC 61853- Part 1/ IS 16170: Part 1	Photovoltaic (PV) module performance testing and energy rating –: Irradiance and temperature performance measurements, and power rating
IEC 62716	Photovoltaic (PV) Modules – Ammonia (NH3) Corrosion Testing (As per the site condition like dairies, toilets)
IEC 61730-1,2	Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction, Part 2: Requirements for Testing
IEC 62804	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation. IEC TS 62804-1: Part 1: Crystalline silicon (mandatory for applications where the system voltage is >600 VDC and advisory for installations where the system voltage is < 600 VDC)
IEC 62759-1	Photovoltaic (PV) modules – Transportation testing, Part 1: Transportation and shipping of module package units
Solar PV Inverters	
IEC 62109-1, IEC 62109-2	Safety of power converters for use in photovoltaic power systems – Part 1: General requirements, and Safety of power converters for use in photovoltaic power systems Part 2: Particular requirements for inverters. Safety compliance (Protection degree IP 65 for outdoor mounting, IP 54 for indoor mounting)
IEC/IS 61683 (as applicable)	Photovoltaic Systems – Power conditioners: Procedure for Measuring Efficiency (10%, 25%, 50%, 75% & 90-100% Loading Conditions)
BS EN 50530 (as applicable)	Overall efficiency of grid-connected photovoltaic inverters: This European Standard provides a procedure for the measurement of the accuracy of the maximum power point tracking (MPPT) of inverters, which are used in grid- connected photovoltaic systems. In that case the inverter energizes a low voltage grid of stable AC voltage and constant frequency. Both the static and dynamic MPPT efficiency is considered.
IEC 62116/ UL 1741/ IEEE 1547(as applicable)	Utility-interconnected Photovoltaic Inverters - Test Procedure of Islanding Prevention Measures
IEC 60255-27	Measuring relays and protection equipment – Part 27: Product safety requirements
IEC 60068-2 (1, 2, 14, 27, 30 & 64)	a) IEC 60068-2-1: Environmental testing - Part 2-1: Tests - Test A: Cold b) IEC 60068-2-2: Environmental testing - Part 2-2: Tests - Test B: Dry heat c) IEC 60068-2-14: Environmental testing - Part 2-14: Tests - Test N: Change of temperature d) IEC 60068-2-27: Environmental testing - Part 2-27: Tests -

	Test Ea and guidance: Shock e) IEC 60068-2-30: Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle) f) IEC 60068-2-64: Environmental testing - Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance
IEC 61000-6-1/3; IEC 61000-3-2/3 (as applicable)	Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) testing of PV Inverters
Surge Arrestors	
IEC 62305-4	Lightening Protection Standard
IEC 60364-5-53/	Electrical installations of buildings - Part 5-53: Selection and
IS 15086-5 (SPD)	erection of electrical equipment - Isolation, switching and Control
IEC 61643-11:2011	Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems- Requirements and test methods
Cables	
IEC 60227/IS 694, IEC 60502/IS 1554 (Part 1 & 2)/ IEC69947	General test and measuring method for PVC (Polyvinyl chloride) insulated cables (for working voltages up to and including 1100 V, and UV resistant for outdoor installation)
BS EN 50618	Electric cables for photovoltaic systems (BT(DE/NOT)258), mainly for DC Cables
Earthing /Lightning	: IEC 62305& IS3043
IEC 62561 Series (Chemical earthing)	IEC 62561-1 Lightning protection system components (LPSC) - Part 1: Requirements for connection components IEC 62561-2 Lightning protection system components (LPSC) - Part 2: Requirements for conductors and earth electrodes IEC 62561-7 Lightning protection system components (LPSC) - Part 7: Requirements for earthing enhancing compounds
Junction Boxes	
IEC 60529	Junction boxes and solar panel terminal boxes shall be of the thermo-plastic type with IP 65 protection for outdoor use, and IP 54 protection for indoor use
Energy Meter	
IS 16444 or as specified by the BISCOMS	A.C. Static direct connected watt-hour Smart Meter Class 1 and 2 — Specification (with Import & Export/Net energy measurements)
Solar PV Roof Mounting Structure	
IS 2062/IS 4759	Material for the structure mounting

Note- Equivalent standards may be used for different system components of the plants. In case of clarification following person/agencies may be contacted.

- Ministry of New and Renewable Energy (Govt. of India)
- National Institute of Solar Energy
- The Energy & Resources Institute
- UV Rheinland and UL

SAFETY GUIDELINES

General Safety:

Contractor shall take all necessary precautions not only for safe working of his own workmen but also deploy all precautions to ensure safety of structures, equipment and workmen of other agencies in and around his work site.

Contractor shall assign an experienced and trained safety In-charge who is aware of all the risks involved in the works related to Installation, testing Commissioning of such Rooftop Solar jobs.

Contractor should conduct daily safety briefing with the team and ensure strict compliance of safety procedures.

Contractor will follow all National and internationally applicable electrical safety norms in installation of solar plant and during operation and maintenance of the plant.

GSCDL/GMC will not be responsible for any clearances and permits.

Contractor shall take permission from Chief Electricity Inspector for setting up the plant, if necessary.

Contractor shall take permission from concerned authorities (Local/state/central) if required under any Laws, rules and regulations.

Any damage caused to existing structure due to construction activities or the operation of the plant thereof will be the responsibility of the Contractor and it will be required to fix the damage as per the specification of GSCDL/GMC or compensate an equivalent amount.

It is responsibility of the Contractor to acquaint himself with the existing policies.

Contractor has to comply with the Environmental, Occupational Health & Safety and Security requirements of GSCDL/GMC and has to ensure that adequate measures have been taken from their end for the safe working of their men and machines.

Contractor shall ensure that his workmen do not trespass into prohibited/restricted work areas.

Contractor shall execute the work in a manner causing the least possible interference with the business of the EMPLOYER/CONSULTANT, or with the work of any other CONTRACTOR who may be engaged on the premises and shall at all times co-operate with the other CONTRACTORS working at site.

Contractor shall obtain daily work permit from the EMPLOYER/CONSULTANT before start of any work at site. The work permits are issued to prevent the CONTRACTOR from working in unauthorised areas and shall be valid for specific area for a stipulated period.

Contractor shall ensure at all times that his workers do not lie down or sleep under or around any machine, equipment, vessel or vehicle in his work area at any time.

Contractor must follow Entry to the project premises with valid Photo ID and mandatory PPE's (safety helmet, shoe & reflective jackets).

The record of Entry / Exit of the personnel will be maintained

Working at Heights

Contractor workmen engaged must undergo medical fitness examination before deploying them for work at heights.

Contractor workers should wear safety full body harness with double lanyard with hook properly fastened.

Contractor workmen engaged on work at heights should be experienced in such work.

Steel scaffold staging should be erected as per IS code. Design for Scaffold staging must be approved by Chartered Engineer.

Wherever multiple work activities Contractor must use safety nets beneath the place of work for safety.

Contractor when working over equipment or tanks, Full body safety harness with double lanyard, safety lifeline and safety nets should always be used whether or not staging and scaffolding is provided.

Safe access to all points of works should be provided in the form of Suitable Ladders /stairways/ boom lifts by Contractor.

Area around the work place should be barricaded suitably or fenced off to avoid Injuries to personnel passing by. Suitable warning boards and sign should be put up by Contractor.

Life line and fall protection arrangements should be provided for working at heights by Contractor

Contractor must ensure loose materials should be cleared on daily basis from scaffolds.

Man-basket not permitted for height works.

Hot Work (Welding / Gas cutting work)

Only qualified welders should be employed at the work site.

Contractor must organise for all welding work at site, Rectifier / Thyristor sets instead of AC transformer sets. AC transformer sets are banned for welding jobs (both open and closed top type).

Contractor should get his welding sets certified by concerned engineer of the GSCDL/GMC before start of the work. These certificates should have to be renewed every month. A copy of the certificates should be displayed on respective welding sets.

Contractor welder should not use the structure etc. as a return path of the current. Adequately rated circuit breaker should be provided in the power circuit for human protection on all power supply points.

Before starting any hot work like Gas cutting, welding and grinding etc., the Contractor should obtain hot work permit from the concerned engineer of the GSCDL/GMC. The permit should be renewed on day-to-day basis.

No combustible material should be stored on or near any source of heat like hot pipes, welding or gas. Before leaving the place of work or the Contractor's sheds, the Contractor's workmen should ensure that no material or item that could start a fire is left at site. Special attention should be paid to collection and disposal of oil soaked cotton waste or rags. On no account are these to be dropped into corners, pushed below equipment or left hanging on pipes.

Contractor must use gas cylinders in a safe manner. These should not be dropped from heights or dragged on the floor. Trolley with rubber rimmed wheels should be used for transporting gas cylinders within the site. All cylinders should be kept in upright position. Oxygen cylinders should not be kept near inflammable materials like oil etc.

Standard colour codes for the cylinder must be followed (Oxygen-Black, Acetylene-Maroon) by Contractor.

Contractor must provide the gas cutting sets with flash back arrestor at both ends (Cylinder and Torch) and gas cutting rubber tube ends fixed with the clamps.

Contractor must provide the fire blankets for fire protection in the vicinity of welding and gas cutting jobs.

Contractor must provide charged fire extinguisher of DCP / CO2 type with each welding/gas cutting set.

LPG shall not be used for cutting / heat treatment purpose (strictly prohibited).

MECHANICAL SAFETY:

Contractor shall ensure that all his equipment and machinery are safe to use while in motion or working. Operators shall have received training or instruction on operation of the machinery and the regulatory requirements.

Contractor shall have adequate procedure to ensure the stability and securing of his working machinery during operation. He shall restrict repair and maintenance of the machinery to trained personnel and maintain records of repairs and maintenance. The equipment shall have appropriately designed means of isolating from sources of energy and shall have emergency stop control, which is easily accessible. All controls shall be clearly and uniformly marked. All operation controls, interlocks, sensing devices and guards on tools and equipment shall be functional and their status shall be regularly checked and recorded. Contractor shall provide evidence of compliance to these requirements in any contractual write-ups submitted to owner /Engineer for approval in respect of critical construction/ contract works.

Contractor shall provide only good quality hand-tools and ensure control of condition, storage, routine inspection and use of such hand-tools. Unsafe tools such as with cracked or broken handles, mushroomed chisels and punches, worn screwdrivers, hardened hammerheads; power tools with unsafe resistance to earth or without safety guards shall be prohibited.

All safety ladders and scaffolding and such access equipment shall meet requirements of IS 3696: and IS 4014:1967 and such standards Engineer/ Owner may stipulate. The safety work permits shall be issued only after ensuring that all safety requirements of access equipment are complied with. Access equipment shall be inspected on a routine basis to prevent injuries caused by falls.

A checklist shall be used for inspection and certification of hand tools, safety ladders, scaffolding and other equipment.

Scaffolds:

- Only MS tubes shall be used for scaffolding.
- Scaffolding shall be erected, altered and dismantled under supervision of authorized person and by person with adequate experience.
- No scaffold shall be left partly erected or dismantled unless adequate notices are displayed and access blocked.
- Scaffoldings shall be mounted only on hard foundations. Bricks, concrete blocks and odd, uneven timber scraps shall not be used for sole plates. Adjustable base plates shall be used in uneven surface.
- Bracing and Ties shall be done to ensure the stability of the scaffold. Bracing shall be done in both directions. Bracing shall be done on the outer face of the scaffold from base to the full height in diagonal manner or along each bay in Zigzag manner. Braces shall be connected to standards using swivel coupler or to the ends of transoms with right angle coupler.
- Scaffold shall be securely tied to the structure throughout their length and height to prevent movement of the scaffold either towards or away from the structure.
- A scaffold should be strong enough to bear the load of the worker and the material. Normally, scaffolds are erected in such a way that they can withstand at least four times the anticipated working load.
- Width of the working platform shall be of minimum width of 600 mm. Boards free from damages/ paint /oil shall be used. Thickness of the planks used shall be from 32-38 mm and width shall be 225-300 mm. Width of the platform shall be decided to suit type of work from 600 mm to 1.5 M Planks shall be decked closely as close as practicable, locked or secured on both ends to prevent tipping and displacement

during normal use. Overhang at least 50 mm but not more than 4 times thickness of the board, unless secured from tipping.

- Provide a safe and convenient means to gain access to the working platform. Keep the platform free from any unnecessary obstruction, rubbish and projected nails.
- Guardrails must be provided on the exposed sides and ends of all working platforms more than 3 m in height. The guardrail may be fixed to the outside of the standard.
- A toe board or equivalent protection must be fitted on the outside edge of every working platform more than 3 m in height, if materials and tools are placed on the platform and are likely to be dislodged. Scaffold plank of 225 mm minimum width may be used as a toe board.
- To facilitate the movement of materials, guardrails and toe boards may be temporarily removed, but they must be replaced as soon as practicable. Scaffolds more than 2 m in height shall be provided with secured ladder fixed at top or bottom for access and it shall extend at least 1 meter above platform.
- Inspect the scaffolding thoroughly before allowing the worker on it. A separate log shall be maintained by the Safety Engineer regarding inspection details and date of next inspection. Proper colour tagging shall be provided for the incomplete and complete with inspection scaffoldings.
- No scaffold shall be kept in partly dismantled condition. If for any reason, the scaffolding is left in partly dismantled condition, a suitable warning sign shall be displayed on or near the scaffold.
- Scaffold location must not foul access ways, roads and doors. If fouling is unavoidable, warning boards shall be installed and the area cordoned off for traffic.

Contractor shall ensure safety of all those concerned with lifting and those who may be affected by material hoisting, lifting and handling using various mechanical aids.

All lifting equipment such as cranes, hoists, lifting shackles, hooks chains and links shall be designed as per appropriate International codes of construction and shall have valid test certificate from competent person. Operators shall have been trained in operation and maintenance of such equipment besides training on standard hand signals to be employed during the hoisting and lifting operations.

- The lifting machines, chain pulley blocks etc. must be tested and valid test certificates should be submitted to the Project in charge.
- Ensure that the chain pulley blocks with locking lever (safety catch) are used.
- Check the wire rope for distortion, kinking, unevenness and general corrosion. Never use ropes, which are having these defects.
- Proper crimping should be done for wire rope joints and ends. Use standard 'U' clamp for tying up the rope and object.
- The safe working loads should be clearly marked on each of the above items. In no case, this rated capacity should be exceeded.
- Never work or move below the suspended loads.

Riding on construction equipment, forklifts and cranes shall be prohibited unless such vehicles are provided with passenger seats.

Pressurised gas and air systems shall be maintained safe in good working order and shall meet the requirements of the Factories Act 1948, The Static and Mobile Pressure Vessels Rules 1984 and the Gas Cylinder Rules 1934 as applicable. The safety relief valves, safety appurtenances and isolation systems shall be compliant with safety code of practices. Any statutory register of pressure vessel records and the code of practices shall be subject to periodic auditing by Owner and Engineer.

The areas of highly dangerous activities like hoisting & lifting, shall be appropriately barricaded to protect personnel and machinery and guided by work permit discipline. Emergency plans shall cater to emergencies arising out of such activities.

Signs, barricades, barrier tapes and warning or entry restriction devices or accessories shall be provided to minimise work related risks of accidents and injuries. Signage shall meet all regulatory requirements such as under The ` and other Construction Workers Act 1996, Factory Act 1948, Manufacture, Storage, Import of Hazardous Chemicals Rules under Environmental Protection Act 1986, Indian Explosives Act 1984 and Gas Cylinder Rules 1981 and Indian Electricity Act 1910 and Rules thereof and any other safety requirements of Owner and Engineer.

Electrical equipment-Safety

Contractor shall provide only such equipment for work that is electrically safe to work. Contractor shall have a procedure to identify and record all his electrical equipment in a register, with provisions to record his periodic inspections of such equipment. Inspection shall cover cables, extension leads, all electrical equipment drawing power from socket outlet. He shall identify and maintain in good working order all electrical installations such as distribution panels and major switchgear ensuring safe accessibility. A clear area shall be maintained around Panels and switchgears. The installed equipment shall be periodically inspected by qualified personnel to ensure their continued safe operating condition. Inspection shall include earth polarity checks, continuity checks and earth resistance checks. Contractor shall ensure use of flameproof and explosion proof switchgears and lighting fittings where required as per governing codes.

Approved earth leakage relays or alternative safety devices conforming to relevant ARE /International codes shall be used on all portable electrical hand tools. Where possible low-voltage electric power supply shall be used for hand-tools. Earth leakage units shall protect electrical installations. Record of regular checks shall be maintained. Contractor shall comply with "Code of practice for earthing" as per IS 3043:1987

Safety rubber matting of appropriate voltage rating conforming to IS 15652:2006 shall be provided in front of all switchgears and power distribution panels for the safety of personnel operating such equipment.

Contractor shall arrange displaying signage under Indian Electricity Act 1910, such as:

- Danger notices as per IS 2551 in conspicuous places on all low, medium and High voltages as per Rule 35,
- Instruction of restoration of persons suffering from electric shock in English and local languages as per Rule 44 in switch gear rooms, substations and places where electricity is used and
- Notice prohibiting unauthorised entry in areas where electrical apparatus are used.

All power cables providing construction power to various construction machinery and the connectors shall be in safe and sound condition. Cables shall be routed through cable trays/ UPVC or DWC pipes supported on appropriately designed structures, duly clamped, secured and identified. Road crossing cables shall be laid in conduits buried atleast 750 mm below the surface to prevent damage due to vehicular traffic. All cables shall be off the floor to avoid damage or tripping hazard. Cables shall be terminated at the switchgears and sockets in a workman like manner to prevent loose contacts and flashover. Only safety receptacles shall be used for providing power connection to hand-tools. All switches and distribution boards shall be clearly marked. All electrical distribution and panel wiring diagrams shall be available with the electrical maintenance personnel. Contractor shall maintain a safe electrical isolation/lockout procedure.

Contractor shall ensure lighting circuits are not used for hand-tools. No electrical equipment shall be overloaded. Tools and test equipment used on electrical systems shall be insulated.

ELCB provided should be rated 30mA

All the electrical work should be carried out by persons holding valid electrical license / certificate.

Bidder's Stamp & Initials

No vehicle or construction equipment shall be parked and operated below / near HT and LT electrical lines.

Use portable grinders, drilling machines, etc. conforming to IS standards. All these tools should be properly insulated.

Never overload cables beyond the rated capacity. This is one of the common causes of fire.

Provide the rubber gloves to electricians who work in HT zone. Ensure that the gloves are tested as per IS 4770 :1968 and the same are approved.

Before commencing repair or maintenance work on any machine, switch off the main supply / remove fuse, display caution tags on machines and switchboards. Follow the standard lock out, tag out procedure.

All equipment should have earthing arrangements.

Do not insert bare wires in sockets for energizing any equipment. Use only plug tops for all electrical equipment.

While laying cables, ensure that cables are so laid that they do not obstruct the smooth movement of men and machinery.

Make sure that all cables are protected against abuses and possible damage.

Use junction / extension boxes for long distances. Open connections are not permitted.

Approved flameproof fittings shall be used in flameproof areas.

Arrange for sufficient lighting, incase work extension is required beyond normal working hours. Obtain necessary approvals for the same.

Check for any underground cables before starting excavation jobs.

No loose cable allowed to cross the Road. If cable is required to cross the road it should hang at certain elevation. No joints allowed without proper connections.

SAFETY IN HANDLING SOLAR PANELS

Read the installation guidelines completely before installing, operating and maintaining the Solar PV Panels.

Contact with any solar panel connected or disconnected to the system is dangerous as the solar cells shall start generating power when they are exposed to light, hence it is imperative that proper care should be taken while storing and handling such panels. Installation of such panels shall be carried out by only trained personnel. Access to unauthorised persons to these areas should be strictly restricted.

Adequate signage in this regards should be installed at the storage and installation site to make people aware of the hazards related to Solar Panels.

All exposed conducting parts shall be well insulated while storing and installing.

Housekeeping in the storage and installation areas should be strictly maintained to avoid accumulation of any combustible material in the surrounding which may lead to fire.

These areas shall be maintained dry. Care should be taken not to damage the panels by keeping/ dropping material on top of it.

Avoid artificially concentrated sunlight beam from falling on the stored panels.

Use proper care while lifting these panels to avoid damage.

HAZARDOUS SUBSTANCES CONTROL

Contractor shall prevent all injuries, illnesses and damage to property or the environment caused by any article or substance, which proves to be hazardous. The code of practices of construction and operation and maintenance and control procedures shall meet required statutory and regulatory requirements. Personnel shall be trained on use, handling, storage and disposal of and emergency spillage procedures.

Contractor shall detail and deploy Operational controls to reduce hazardous wastes and their disposal as required by the statute “Hazardous Waste (Management and handling) Rules 2008”. Oil wastes, used oils, soil and cotton soaked in oil consequent to handling operations, grease and many class of paints and asbestos sheets and gaskets are typical hazardous wastes.

Contractor shall identify, contain and control all sources of radiation. Appropriate regulatory approvals shall be obtained before commencement of work involving radiation sources. Radiation protection advisors suitably qualified and experienced shall be appointed whose names shall be submitted to owner/ engineer. Dosimetry and surveillance of personnel engaged in such work shall be maintained in accordance with regulatory requirements.

PERSONAL SAFEGUARDING

Personal protection equipment (ppe): General

Contractor shall provide his employees required PPE meeting the requirements of the stated IS Specifications and Guidelines or equivalent International Standards as may be prescribed by the Engineer from time to time. Contractor shall have instituted good working procedures and practices in providing PPE, maintenance, issue and training on their use. All PPE shall be periodically checked to ensure worn, damaged equipment are replaced expeditiously.

- Control of use of issue, use and maintenance of PPE - Employees shall be responsible for PPE issued to them. Contractor shall meet requirements of IS 8519: 1977 titled “Guide for selection of Industrial safety equipment for body protection” or any equivalent international Specification that the Engineer/Owner may prescribe.
- Head Protection - Contractor shall comply with requirements as per IS 2925. Hardhats shall be used and worn where a hazard of falling or flying objects exist. Hard hats intended for use by visitors shall have replaceable paper lining. Wearing of helmets inside the project site is compulsory. Colour coding of helmets may be followed for different category of personnel working at the site / visitors.
- Eye and face protection - Eye protection shall be worn during all operations by operators and people in the vicinity, where there is a danger of flying particles of metal such as generated during use of hand tools such as chisels, grinding, welding and cutting lathe work on brass and cast iron, acid and alkali splash, and high pressure jet cleaning or insulation removal from heights using high pressure jets. Contractor shall meet the requirements of IS 8520 titled “Guide for selection of Industrial safety equipment for eye, face and ear protection”.
- footwear - Safety shoes, boots and gumboots fitted with steel toe-caps of approved quality conforming to prescribed Indian or international standards. Wearing of unsafe safety shoes such as jogging shoes, tennis shoes, slippers and sandal etc. are prohibited. Contractor shall meet the requirements of IS 10667:1983 titled “Guide for selection of Industrial safety equipment for protection of foot and leg”.
- Protective clothing - Contractor shall prevent hazards of loose clothes worn by workmen getting caught in moving machine parts. Loose and thin garments such as Dhoti and pyjamas shall be prohibited. While Contractors shall ensure that all workmen wear long sleeved shirts, jackets or the like with the sleeves rolled down and secured at the cuff, long pants/ trousers extending upto the top of the safety shoes so as to prevent injuries caused by contact with heat, cold abrasive and sharp surfaces shall be strictly enforced. Contractor shall meet the requirements of IS 8990:1978 titled “Maintenance and care of industrial safety clothing.” Women wearing saree and other loose dress should wear outer jacket / shirt. It is suggested to wear reflective jackets for better visibility.
- Hand Protection - Contractor shall provide appropriate hand gloves as per IS 8807:1978 titled: “Safety equipment for protection of arms and hands” to prevent injuries to hands during work. Contractor shall maintain appropriate inventory of gloves for different applications like Acid/ alkali handling, general-purpose work gloves and asbestos or heat resistant Hand gloves etc.

- Safety harness/ fall arrest - Contractor shall provide safety harness or means of restraint such as safety Belts, harness and lifelines etc to workmen engaged to work in heights such as Open –sided Floors, Open-sided scaffoldings, floor and roof openings, overhead construction works of various nature etc where there is a falling hazard of six feet or above. To prevent any fall from a height of 2 Metres or above. Storage, issue wearing and maintenance of safety harness shall be under strict supervision and records shall be maintained. Safety belts should be tested and certified by competent person. All fall arrests shall consist of full-body harnesses, lanyards with shock absorbers, lifelines, rope grabs and associated hardware. Two alternate lanyards shall be used to facilitate tying off at a new location before disconnecting from the previous location's of practices for safety harnesses and fall arrests shall conform to IS 4912:1978, IS 11972:1987, IS 8519:1977 or equivalent international codes.
- Falling object protection - Where work is in progress in elevated areas, barricades, barrier tapes signs and such entry restriction devices shall be used to keep area below clear of personnel to prevent injury due to falling objects. If work is required in the area below elevated work area, it shall be scheduled at a time different from elevated works. The workmen below shall be protected from falling objects by the debris net or a catch platform with an adequate toe board to prevent material from falling off. Use of safety net for elevated works shall be considered in the work-permits where appropriate. Where a lift is made above a working area, the area below the path of the lift shall be cleared of personnel during the lift and barricaded and guarded to prevent entry of persons generally in conformity with IS 4912, IS 11972 and IS 13416 "for protective barriers in and around structure and preventive measures against safety hazards in work places and safety requirements for floor and, wall opening, railings and toe-boards." Hard barricading shall be provided for excavation more than 2 meter deep.
- Hearing conservation - Contractor shall ensure reasonable precautions are taken to avoid injury to the hearing of the employee. All noise levels shall be controlled within 90 dBA. Contractor shall identify noise areas where noise levels exceed prescribed safe level for arranging for appropriate Engineering revision. Where this is not feasible, appropriate Earmuffs or protectors shall be provided to workmen ensuring they are worn by those exposed to noise levels beyond safe levels. Periodic hearing acuity tests shall be conducted on such persons exposed to high noise levels to ensure that they do not suffer any hearing impairment` as per requirements of IS 8520: 1977

Manual handling: & ergonomics

Contractor shall have procedures to identify risks involved in manual handling operation and tasks. He shall ensure appropriate training to prevent any possible injury. Full use of mechanical aids shall be made to avoid risks arising out of such manual handling. Employees shall be adequately trained on such manual tasks and related safety precautions to reduce the risk of injury to personnel engaged in such work.

Contractor shall undertake ergonomic study of manual operations to prevent musculoskeletal injury during manual handling, besides visual fatigue and mental stress giving considerations to matters such as seating. Lighting and ventilation etc. Person should not lift / carry more than 50 Kg load.

PREMISES AND HOUSE –KEEPING

Contractor shall maintain a well-managed safe working place in sound clean condition. Contractor shall ensure that there is a place for everything and everything in its place so that optimum use is made of valuable floor space with commensurate cleanliness and reduced handling time. He shall ensure that his entire infrastructure is kept clean and good repair.

All temporary constructions like rest sheds, storage sheds etc shall be constructed using MS pipes and GI sheets only. The temporary sheds shall have substantial strength to withstand local site weather conditions.

Contractor shall provide lighting, natural or artificial, to enable carry out work processes safely. Artificial lighting shall be adequate especially in the nights and emergencies. The lumen levels shall meet the statutory requirements.

Movement of Equipment and machinery

Before starting the activity, plan properly by examining the route, taking measurements, if needed, to ensure that sufficient clearances are available.

While planning the route, look for overhead cables, pipelines, guide ropes and other protruding objects.

Use properly rated trolley to move the equipment / machinery.

Ensure no damage to the walls, or other surrounding machinery during movement. Make clear to all the fellow contract men about communication system, to avoid misunderstanding.

If you are moving smaller items like pipelines etc. ensure that these items are properly secured and tied.

Proper sling arrangement to provided for crane in case of lifting equipment to a elevated height. No person is allowed to lift with equipment.

Stacking and storage practice

Contractor shall ensure stacked material is bonded on a stable and level footing capable of carrying the mass of the stack. Adequate clearances shall be provided between the sides of the stack and top to facilitate unimpeded access to service equipment like overhead wiring, cranes, forklifts and firefighting equipment, and hoses. Circular items shall be sufficiently choked with wedges not with odd bits of materials. Free-standing stacks of gunny bags and sacks such as Cement bags shall be stacked to prescribed safe-stack heights with layers formed for stable bonding, preventing slippage causing accidents. Stacking against walls shall not be permissible.

Contractor shall maintain the premises and surrounding areas in clean and clear manner with safe access and egress. There shall be sufficient and adequate storage racks, shelving, bins and pallets and material handling equipment to stack his construction materials such as Pipes, structural and his construction enabling materials. Unwanted materials shall be promptly moved away for efficient material movement.

Scrap and Refuse Bins-Removal System

Contractor shall ensure that he has sufficient waste bins that are identified for different wastes and maintained in clearly demarcated areas. Wastes with oily or other ignitable materials such as Oily cotton wastes and Hand gloves shall be stored separately with covers to prevent fires and shall be made of metal. Different Wastes shall be segregated and stored separately and disposed off. They shall be emptied at routine intervals to prevent that they do not overflow with wastes.

Emergency Planning / Emergency Response

Contractor shall plan to deal with on site emergencies. An emergency planning/emergency response specific to the job site shall be written and communicated to all employees. The emergency planning/emergency response shall identify for the potential for and responses to incidents and emergency situations and for preventing and mitigating the likely illness and injury that may be associated with them.

17. DIESEL GENERATOR SETS**SCOPE**

The scope of this section consists of but not necessarily limited to the following in accordance to Technical specification prescribed in tender. The contractor shall supply, deliver to site, hoisting into position, install, test and commission the Prime rated power generating set together with the necessary controls and switchboards as specified and indicated in the Drawings.

Protection circuits, control wiring and interlock circuits not specified or indicated in the Drawings, but deemed necessary for the safe operation of the generating system shall be provided without any additional cost to complete the system. Provide manufacturer's factory representative's services, including coordination, and start-up and testing supervision.

Testing (factory and field), start-up supervision, training and providing necessary documentation and tools for operation. Carry out performance test run at site with Load bank & Lube oil etc. arranged by contractor.

CODES AND STANDARDS

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations, and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

DIESEL ENGINE

Diesel Engine shall be of proven design, multi-cylinder direct injection; turbo charged compression ignition type, operating at a speed of 1500 rpm and shall be silent, vibration free while in operation and comply to latest Centre/State Pollution Control Board & local authority norms and shall conform to ISO 3046,8528-1 / BS 649,5514. The fuel grade shall be high speed diesel.

The engine shall be complete with radiator cooled (coolant) type engine, fan, lubricating oil pump, lubrication oil pressure gauge (microprocessor built-in display), tachometer, digital or electronic type governor, integrated hours-run recorder, over-speed trip and all other necessary auxiliaries.

The engine speed shall be regulated through an electronic governing system which shall also provide the over speed protection. The governor shall ensure that the speed of the set is regulated within 1% of the nominal speed under normal operating conditions.

The brake horsepower of the engine with all attached accessories as specified shall not be less than that which is required by the full load rating of the alternator at site operating conditions taking into consideration losses, plus a reserve factor of at least 10%.

The engine shall be suitable for Prime power application and should be capable to run on 10% overload for 1 hour duration in every 12 hours of operation as per ISO regulations.

Lube Oil System

Lube oil system shall be complete in all respects but not limited to the following:

Engine Mounted Lube Oil Sump.

Engine operated lube oil pump.

Plate/ Shell and tube type water cooled lube oil cooler.

Full flow paper cartridge type oil filters.

All necessary piping, valves, specialities, instrumentation and supports

First fill of lube oil and all other lubricants, greases and consumables.

Unless otherwise specified in Data sheet, thermostatically controlled electric heaters for lube oil shall be provided, if ambient conditions warrant the same.

Engine Cooling System

The Engine shall be provided with Radiator for cooling the engine as well as the body and the cooling system shall be complete, but not limited to the following:

Radiator with engine driven fan

Engine driven circulating pump

Expansion tank

Anti corrosion cartridge

All necessary piping, valves, specialities, instrumentation and supports.

Thermostatically controlled jacket water pre-heater, if required.

DG Starting System

Starting of the DG shall be automatic and manual.

Electric starting system, the same shall be complete, but not limited to the following:

- Starter motor
- Maintenance free batteries, with capacity suitable for minimum three (3) continuous Cold starts
- Engine driven Battery charger

Air Intake System

The Air Intake System shall be complete, but not limited to the following:

Engine mounted Air intake filter and silencer.

All necessary piping including, specialities like bends, flanges, expansion joints, etc.; and supports.

Air Exhaust System

The Air Exhaust System shall be complete, but not limited to the following:

Residential type Exhaust gas Silencer.

All necessary piping from Diesel Engine up to Exhaust gas silencer including, specialities like bends, flanges, expansion joints and insulation.

Exhaust Stack and Exhaust Piping

Exhaust stack, if specified in data sheet A, shall be self-supported and designed as per IS 6533. The stack shall be complete with all accessories and insulated up to a height of two (2) meters from ground level.

The exhaust piping shall be fabricated from 6mm thick MS pipes.

Stack height shall be maximum of the following, in meter:

1. $14 Q^{0.3}$, Q= Total SO₂ emission from the plant in kg/hr.
2. Minimum 6 m. above the building where generator set is installed.
3. 30 m.

Fuel Oil System

Fuel oil system external to engine shall be complete in all respects but not limited to the following:

Day tank with secondary containment trays and structural supports

One number of SS wire braided Flexible Hose.

All piping, valves, specialities, instrumentation and supports between day tank and engine.

Day oil storage tank shall be fabricated from 4 mm thick MS plates.

The day tank, as minimum, shall have following accessories:

Inlet connection with filter and flange

Inlet connection for return from fuel pump

Outlet connection with valve

Drain connection with valve

Overflow connection with flange

Vent connection with flame arrestor.

Manhole for cleaning

Level gauge with isolation valves

Two (2) numbers of level switches with two independent switch contacts each, for 'High' and 'Low' oil Level.

All pipes shall be of carbon steel pipes: ASTM A 106 Gr. B as per ASME B 36.10.

All valves shall be of ASTM A 216 Gr. WCB, 150 CL., RF and fire safe AF 51/52.

The piping shall be painted with one coat of primer and two coats of finishing paint of approved colour.

GENERATOR**GENERAL**

The line and neutral ends of each phase winding of the generator shall be brought out on six (6) suitably located terminals.

If the termination will be through cables, the size of the conductor cables, to be provided by the PURCHASER, will be furnished during detailed engineering. Suitable clamping arrangement shall be provided for connecting the cables to the machine terminals. The terminals shall be suitably enclosed to prevent short circuits by rodents etc. Suitable cable

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glands shall be provided on the enclosure to facilitate entry of the cables.

If the termination will be through Busduct, the terminal arrangement shall be provided suitable for busduct and the necessary details shall be furnished during detailed engineering.

The connection between the generator phase side terminal box and the breaker isolation panel to be provided by the Bidder shall be through Non segregated phase bus duct which also will be in Bidders scope.

240 V single phase space anti-condensation heaters of adequate ratings shall be provided in the lower part of the stator frame.

The generator shall be provided with two (2) grounding terminals with clamps suitable for connection to the PURCHASER'S grounding grid.

The generator shall be provided with winding and bearing RTDs, if specified in data sheet A.

EXCITATION SYSTEM

The excitation system shall be as specified in data sheet A.

The response ratio of the excitation system shall not be less than 0.50.

The excitation system shall be so designed and/or protected, that harmful over-voltage cannot occur at the main exciter commutator due to combined effect of maximum exciter field current and machine over-speed.

VOLTAGE REGULATOR

The generator shall be capable for operating over a range of $\pm 5\%$ of the rated voltage, unless specified otherwise in data sheet A.

The voltage regulator shall be supplied complete with cross-current compensation preferably of the static type. The regulator shall be supplied complete with voltage setting device, all accessories and alarm contacts.

CONTROL SYSTEM

Auto mains Failure (AMF) feature shall be provided by the vendor.

The DG shall be normally at rest when the AC supply is available from normal power source. In case of normal AC supply failure, the DG shall be started as follows:

For Automatic Main Failure (AMF), an impulse from under voltage relay shall automatically initiate the DG starting sequence. After attaining the rated speed and voltage the isolation breaker shall be closed automatically through AMF. Also necessary potential free contacts (4 NO+ 4 NC) shall be provided by Vendor in AMF panel for Purchasers use to close the incoming breaker at receiving end Panel. Provision for starting the DG through remote push button through auto/manual, local/remote selector switches initiating the same starting sequence shall also be made.

For AMF start, minimum three (3) attempt starting facility shall be provided and in case the DG fails to start and reach rated speed within 30 seconds, it shall be disconnected and locked out automatically. For battery started sets this aspect shall govern the battery Ampere Hour rating.

Unless specified otherwise in data sheet A, stopping of the DG for a normal shut-down shall be done manually by means of push button either locally or remote.

Engine and alternator control panel with protective, monitoring and control devices, annunciation, interlocks, indicating lamps etc. shall be provided.

GOVERNING SYSTEM

The governor characteristics shall comply with the requirements of class of ISO 3046, unless specified otherwise in data sheet A.

The governor shall be provided with an electrically operated speeder gear for remote adjustment of generator frequency, suitable for operation on DC voltage, if indicated in data sheet A.

The governor shall be capable of responding to a step change of load either switch-in and/or throw-off as specified in data sheet A such that all operating parameters are within limits.

CONTROL, PROTECTION AND METERING

Microprocessor based control panel for DG set shall have protection, meters and alarm annunciation windows. DG control panel shall have minimum following control facility :

Local/Remote : Auto/ manual / test/off

Speed : raise/ lower

Voltage : raise/ lower

AVR reference voltage setting

Trip/ close

Emergency STOP

The DG set shall have manual control on following operations and facilities when the Auto/ Manual switch on the DG Panel is in Manual mode :

DG Start/stop

Speed raise / lower

Voltage raise / lower

Close the DG Isolation breaker

When the Auto/ Manual switch on the DG Panel is in Auto mode, following operations shall be done automatically without any operator intervention:

DG Start/Stop

Speed raise / lower

Voltage raise / lower

Close the DG breaker

Load DG set

Interlocking Arrangement

Necessary interlocking arrangement shall be made with Purchaser's breaker; however, the same shall be subject to the purchaser's approval.

Annunciators

Window type annunciators shall be supplied and mounted on each DG control panel to give visual and audible indication for the following conditions. The annunciation list shall be subject to approval of the PURCHASER.

Isolation Circuit Breakers

Type:

Circuit Breakers shall be of the air break, fully draw out type. Circuit breakers shall comprise three separate identical single pole units operated through a common insulated shaft by the operating mechanism.

Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds.

Each breaker shall be provided with auxiliary contacts of 4NO + 4NC directly operated from breaker operating mechanism. These contacts shall be in addition to those used in circuit breaker internal wiring. These contacts shall be rated for 10A at 240V AC and 5A (inductive breaking) at 110V DC. If more breaker auxiliary contacts are required, latched type relays shall be used to multiply the contacts. All these contacts shall be wired to terminal box for Purchaser's use.

There shall be 'Service', 'Test' 'Fully withdrawn' positions for the breakers. In the 'Test' position the circuit breaker shall be capable of being tested for operation without energising the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected. Separate limit switches, each having a minimum of 2 'NO' + 2 'NC' contacts shall be provided for both 'Service' and 'Test' positions of the circuit breakers for Purchaser's use. These contacts shall be rated for 10 amps, 240 V AC and 5 amps (inductive breaking) at 110V DC.

The circuit breakers shall be provided with the following:

Mechanically operated targets to show 'Open', 'Closed', 'Service' and 'Test' positions of the circuit breakers.

Mechanically operated, red 'trip' push button, shrouded to prevent accidental operation.

'Red', 'green' and 'amber' indicating lamps to show 'Closed' 'Open', and 'Auto-trip' conditions of the circuit breaker.

Closing and trip coil shall operate satisfactorily under the following conditions of supply voltage variation :

Closing coils - 85% to 110% of rated voltage, 110V DC

Trip coils - 70% to 110% of rated voltage, 110V DC

Circuit breakers shall be provided with facilities for remote closing and opening operations.

Power operating mechanism shall be provided with following additional features :

Closing of the circuit breaker shall automatically initiate recharging of the spring ready for the next closing stroke.

The motor shall be mechanically decoupled as soon as the emergency manual charging handle is inserted.

Mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and will not cause tripping or closing operation of the power operated closing devices. When the circuit breaker is already closed, failure of any auxiliary spring shall not cause damage to the circuit breaker or endanger the operator.

Breaker operation shall be independent of the motor, which shall be used solely for charging the closing spring.

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Motors shall be rated for 240 V AC tapped from input side of DG breaker and shall operate satisfactorily at all values of voltage between 85% to 110% of rated voltage. Motor shall be protected against overloads and stalling.

MCCB

For all MCCBs, Ics shall be selected as 100% of Icu.

All protective components especially MCCBs shall be with Utilisation Category "B" (i.e. offering time discrimination with downstream devices).

MCCBs shall be of current limiting type. Operating mechanism shall be quick-make, quick-break and trip-free type.

The instantaneous short circuit release of MCCB shall be so chosen by the VENDOR as to operate at a current in excess of the peak motor inrush current and a range of settings shall be provided for the PURCHASER'S selection.

MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.

Protection tripping of MCCB shall be identified with Trip/Alarm contact.

The ON, OFF and TRIP positions of the MCCB shall be clearly indicated and visible to the operator and one contact of each shall be brought out for PURCHASER's use.

LOCAL PUSH BUTTON STATION

The Local Push Button Station shall be furnished in sheet steel or cast Aluminium enclosure (minimum 2.0 mm thick) of weatherproof gasketed construction with dust and vermin proof suitable for outdoor use without canopy conforming to IPW-55 or better.

The enclosures shall be suitable for mounting on column/wall and complete with push button, anodized aluminium inspection plate, earthing terminal and knockout for cable/conduit entry from top and bottom. The thickness of enclosure sheet shall be 14 SWG.

The push button station shall be provided with separate terminal blocks so that outgoing cabling shall be terminated in these terminals and not directly to the push button terminals. Push button station shall be provided with removable gland plate along with double compression type glands.

The open/close/start push buttons shall be of momentary contact push to actuate type and stop push buttons shall be stay put type with mushroom knob. The stop push button shall be of lockable type in 'OFF' position.

All push buttons shall be fitted with two (2) normally open and two (2) normally closed contacts rated for 415V, 10A.

PERFORMANCE GUARANTEES

The DG and accessories shall be so designed as to meet the following performance requirements:

The DG shall be capable of starting from cold condition, reaching synchronous speed and taking up load within the period specified from the 'start' impulse and shall be capable of delivering continuously at the generator terminals a net output specified, with invisible exhaust.

With the DG running at no-load, rated voltage and speed, the transient voltage drop at its terminals shall not exceed specified percentage of rated voltage, on starting a specified capacity induction motor direct-on-line or star-delta as specified in data sheet A. Governor response, over-speed trip and speeder gear capability, voltage regulator response, excitation

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at full load and under specified variation of voltage and speed shall be guaranteed.

Performance parameters to be guaranteed by the CONTRACTOR and tolerances permitted shall be as indicated in Data sheet A. The BIDDER shall confirm acceptance of these by indicating values in Data sheet A. DG set or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

DATA TO BE FURNISHED BY THE CONTRACTOR AFTER THE AWARD OF CONTRACT

List of drawings and documents to be submitted for review, approval and information with scheduled submission dates.

Quality Assurance Plan (QAP)

Detailed P&I diagram clearly showing the scope of supply of equipment, piping with line sizes and material specifications, valves, specialties, instrumentation, and control and all the accessories. All equipment, lines, valves, specialties, and instruments shall be tagged as per the PURCHASER's procedure to be given to the successful BIDDER. All terminal points shall be clearly identified. All design data and other information furnished in data sheets A shall be covered either in this drawing or other relevant drawings or documents mentioned below.

Detailed equipment list and bill of materials of all items in the CONTRACTOR's scope

Sub-vendor list for all bought-out items

Dimensioned to-scale equipment layout drawing showing all equipment, accessories, relevant external dimensions, location and elevation of terminal points, details of piping, ducting and electrical connections to be made by the PURCHASER, clearances required for erection, dismantling, operation and maintenance

Dimensioned cross-section drawings of proprietary equipment like pumps, etc. with part list and materials of construction

Manufacturer's outline drawings, data sheets and performance curves for pumps and compressors etc.

DG, fuel oil system, lube oil system, engine cooling system, air intake and exhaust system, governing system and instrumentation and control system write-up

Detailed fabrication drawings for all fabricated equipment like tanks along with complete mechanical design calculations

Line designation schedule for all lines in the CONTRACTOR's scope

List of valves, specialties and instruments in the CONTRACTOR's scope with tag numbers, type, makes, pressure ratings, materials of construction and ranges for instruments etc.

Manufacturer's drawings, data sheets and catalogues for valves, specialties and instruments etc.

Dimensioned to-scale piping layout drawing for piping in the CONTRACTOR's scope with allowable forces and moments on the piping nozzles and displacement of the nozzles

Overall foundation plan, base frame drawing for each equipment, static and dynamic loads on each of the anchor bolts and dimensional details of pockets and anchor bolts

Electrical control wiring diagrams with all interlocks

Control philosophy, interlock description and logic diagrams

Dimensional to-scale general arrangement and section drawings of DG control panel & Protection with complete bill of materials

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List of alarms and trip settings

Wiring diagram of various sensing devices mounted on engine, air receiver etc., generator control panel, switch-gear panel, automatic voltage regulator, governor and excitation system

Control schematic for synchronising scheme for generators in parallel with themselves as well as with grid, whenever applicable

Cable schedule for interconnecting cabling between DG set and control panel

Generator parameters

Erection, start-up, operation, and maintenance manual complete with lubrication schedule etc.

TESTING:

Inspection and testing shall be carried out based on latest revision of this specification and approved vendor drawing certified for construction. Purchaser shall have right to carry out stage inspection and shop visit to review the manufacturing progress.

However, manufacturer need not hold any manufacturing activity for witness of purchaser/consultant's stage inspection. All routine and type tests shall be carried out during final inspection.

A. Factory Tests: The Factory tests shall incorporate the following: —

Routine Tests of alternator and Engine at respective manufacturer's works. —

Load Test of the complete DG set with control panel at UPF at 100% load about 4Hrs. (FAT) and 1 Hrs. (FAT) on 110% load. Total 5 Hrs. FAT.

Fuel consumption tests by using flow meters. (Fuel costs shall be included)

These tests shall be conducted, and the original test certificates shall be furnished.

Copies of type test certificates conducted on similar type of D.G. set shall also be submitted.

1. DG set starting time

2. Fuel consumption test

SITE Tests: After the erection and wiring and earthing of D.G. Set the tests as stipulated by the manufacturers shall be conducted.

a) Insulation resistance of the generator.

b) Speed, no-load voltage and full load voltage regulation.

c) Load Test of the complete DG set with control panel at 100% load 8 Hrs. (SAT) and 1 Hrs. (SAT) on 110% load. Total 9Hrs. SAT.

d) Fuel consumption tests by using flow meters.

e) Sequence checking, interlocks checking, measurement of starting time, loading of generator etc. shall be carried out by the vendor.

f) Vendor shall supply first fill of lubrication oil & fuel oil.

g) Statutory clearance: VENDOR shall be responsible to obtain following clearances:-

- Electrical Inspector (CEA) clearance
- Supply authorities (State Electricity Board) clearance
- State Pollution Control Board clearance.

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h) Testing of Controls: All the safety controls and protective device of the D.G. set shall be tested for correct calibration and operation. The results of the tests shall be tabulated and submitted in triplicate.

The reading shall be observed with calibrated meters. Only one meter shall be used for the test. The readings shall be properly tabulated and submitted in triplicate.

The BIDDER, at no extra cost, shall provide all instruments, load banks, consumables (like Dube oil, HSD, Filters etc) and accessories required for testing and commissioning of the items specified for the required duration of test.

ACOUSTIC TREATMENT FOR DIESEL GENERATING SETS/ ROOMS

(Note- DG Set should be with Acoustic enclosure. Room Acoustic Requirements is Not Applicable for this Tender)

SCOPE

The scope of work covers providing Acoustic Enclosure to reduce the noise from Diesel Generating Sets as required in the schedule of work.

DESIGN CRITERIA

The design criteria shall be that the insertion loss across the enclosure/ room acoustic lining shall not be less than 25dB as per CPCB while the Average sound pressure level at 1m from any part of the enclosure shall be not more than 75dB as per CPCB. The enclosure shall provide for an air intake, engine exhaust outlet, cable, and fuel pipe entries. A control & monitoring panel shall be accessible from outside with toughened glass cover. An emergency trip device shall be provided in the control panel.

The enclosure should also accommodate a breaker panel appropriate for the set capacity. Access door shall be suitably gasketed so that the opening does not degrade the integrity of the acoustic enclosure. In the case of sets larger than 1000 KVA, the DG room should be acoustically insulated meeting the above noise criteria.

ACOUSTIC INSULATION

Wall & Ceiling Acoustic

Walls and ceilings shall be acoustically insulated wherever shown on drawings or as required by the Engineer-in-charge. The wall/ceiling surface shall be cleaned and a grid work of 600 x 600 to max 1000 x 1000 shall be made using 50 x 50 x 0.8 G.I pressed steel forms. 50mm rock wool covered with tissue cloth shall be cut to size and positioned within the grid work and held with 1.0 mm galvanised steel wire at 300 mm intervals. Entire insulation shall be covered with 0.8 mm thick aluminium sheets having 3 mm perforations at 5 mm staggered centres.

The sheet shall be neatly cut and the edges reinforced with a 20 mm sheet fold and made into neat looking panels. The panels shall be fixed on the frame work using cheese headed No. 8-20 mm sheet metal CP brass screws at 300 Mm centres. Where the insulation thickness is 100 mm the channels shall be 50 x 100 and the remaining work shall be as specified above.

The materials for acoustic insulation shall be as follows:

Application		Material		Sound Absorption Coefficient at				
Octave Mid band frequency HZ								
250	500	1000	2000	4000				
Walls & Ceiling 64 Kg/Cum 50 mm thick		Rock Wool		0.76	1.04	0.75	1.15	0.83

Ambient Air is drawn through louvers and drawn over alternator and engine(to pick up radiant heat) by means of Radiator Fan mounted on the DG Engine and exhausted outside through louvers. Also, the radiator fan shall be selected considering the air flow rate required to maintain the temperature and also the static pressure drop across louvers, sound attenuators, exhaust duct etc.

The sound attenuators to be provided on the fresh air intake and exhaust louver openings of the DG Room. DG room ventilation shall be provided by the vendor. These fans shall be selected to maintain minimum room ventilation of 2 air changes/hour or to take care of the heat radiated to the heat radiated to the room. This fan shall continue for certain period of time even after the DG set is switched off. Necessary interlocks for the same to be built in the panel. Multiple fans to be selected to meet the cumulative capacity. Fan selection calculation shall be furnished by the vendor along with equipment datasheets. The system shall be designed such that the room temperature inside DG room shall not exceed 5 Deg C above ambient dry bulb temperature. The feeder for this shall be provided from the proposed DG distribution board.

The fans are provided with attenuators. It is required that the pipe, duct opening has to be thoroughly sealed. The double doors of the DG room are also to be acoustically treated and fire rated for one hour. The fresh air opening/exhaust fan attenuator shall be provided with aluminium, powder coated louvers to prevent water entry into the same. Vendor shall furnish all information required for the DG room civil construction. These details shall include foundation details, necessary opening required for louvers and fans, supporting details of chimney, pipes etc.

RECD'S (RETROFIT EMISSION CONTROL DEVICE)

Manufacturer shall provide appropriate Retrofit Emission Control Device (RECD) to meet latest emission norms stipulated in Central / State / Local pollution control boards. In case of multiple emission norms are available from boards, stringent among the latest to be followed. The Retrofit Device shall be designed based on the filter-less technology by utilizing Electrostatic Precipitation principle.

RECD shall be capable of removal of suspended particles such as dust and acid mists etc. from flue gas by charging the particles and precipitating them by applying a strong electric field. RECD working shall be generally in accordance with following working principle: The device will be installed in the line of DG exhaust pipe. While flue gas pass through the electrostatic field created within RECD.

Surface of particulate matter acquires electrical charge and it get attracted to electrodes of opposite charge.

The PM gets agglomerated and the size of the PM increases beyond PM10 (10 microns).

The agglomerated PM is collected in powder form and is available for environmentally safe disposal/reuse.

Vendor shall furnish Performance Test Certificate from an authorized test lab approved by CPCB. RECD shall be designed, constructed and capable of being mounted on open terrace so as to enable the application to comply with the rules set out by CPCB/NGT throughout the normal life of the RECD under normal conditions of use. A RECD shall be durable and shall be designed, constructed and capable of being mounted on open terrace so that reasonable resistance is obtained to phenomena such as the corrosion, oxidation, vibration and mechanical stress to which it will be exposed under normal conditions of use.

Devices that by-pass or reduce the efficiency of the RECD are not permitted and shall be considered defeat device or strategy. RECD shall be fitted with an on-board diagnostics and operator warning system that signals to the operator/control room the presence of a failure affecting the efficiency of the RECD. A particulate reduction RECD shall be equipped with a monitoring device that detects incorrect operation or removal of the RECD and that triggers an audible and/or visual alarm to the operator. The warning system can be based for example, on the continuous measurement of the engine exhaust backpressure.

The RECD shall be fitted with particulate control diagnostics with ability to diagnose and trigger operator warning system when confirmed fault/s is detected as per stated requirements below.

- complete loss of particulate capture function.
- Removal of the RECD system
- Failure of the RECD system.
- detection of exhaust bypass, temporary or permanently as part of a field/operator tampering or as a design architectural requirement.

The RECD shall demonstrate all the above particulate diagnostics conditions during commissioning process. Particulate diagnostics system shall register self-healing and non-erasable fault codes in its on-board memory or any capable alternative such as but not limited to connected cloud-based storage along with a time counter to track fault code active period. Such fault code active period shall be utilized for operator inducement.

Operator warning system through audible shall activate once confirmed fault code is registered. intensity of the audible warning system shall be at 100 dB sound pressure measured at 1 meter level at least at the location external to RECD where audible alarm device is mounted. It is also recommended to have visual warning in the form of 'flashing RED light' on the RECD control panel if such control panel provision is made.

RECDs installed with provision of audible and visual operator warning system both, can provide audible warning temporary 'snooze' function with snooze timer not more than 12 hrs. duration. The RECD shall be fitted with operator inducement system that will disable genset operation. The RECD manufacturer shall furnish written instructions about the RECD system and its correct operation to be provided to all operators /control room of DG sets. These instructions shall state that if the RECD system is not functioning correctly, the operators /control room will be informed of a problem by the operator warning system and that activation of the operator inducement system as a consequence of ignoring this warning will result in DG set being unable to re-start.

The instructions shall indicate requirements for the proper use and maintenance of the RECD in order to maintain its emissions performance. RECD shall meet the particulate matter emission reduction limit values 70% as specified in latest order of CPCB/NGT/PCB. The reduction means before and after of RECD which needs to be proved with approved lab test report.

The reduction level of a RECD system is characterised by means of its reduction efficiency as specified. The reduction efficiency shall be determined by comparison of the emissions measured over the weighted specified test cycle for RECDs to be applied to DG set engines. The reduction efficiency shall be calculated from the measured emissions of the relevant pollutant downstream of the RECD (EREC) and the engine system emissions measured

before fitment of the RECD (EBase) for that pollutant, both measured in accordance with the procedures defined in this CPCB/NGT Regulation. If two particle measurement systems are used in parallel for measurement of the particle reduction efficiency, they shall give measurements within 5 per cent of each other when measuring simultaneously from the same sample point.

Reduction efficiency (percent) = $(1 - (\text{EREC} \div \text{EBase})) \times 100$. NO₂ emissions requirements
There shall be no increase in NO₂ emissions above the NO₂ baseline emissions.
Secondary emissions requirements

The RECD system shall provide documentary evidence to show that materials and processes used in the RECD do not present any additional hazard to health and the environment. The RECD shall not increase secondary emissions to concentrations known to be hazardous to health.

The RECD shall be so designed that it can be used in its intended applications, when fitted in accordance with the supplied instructions, without exposing operators or bystanders to any safety hazard either directly or as result of modifications to the DG set or its operating characteristics.

The RECD shall be so designed that it can be used in its intended applications, when fitted in accordance with the supplied instructions, without impairment of the operating behaviour of the DG set unless,

- The impairment does not cause a safety hazard.
- The impairment does not increase the fuel consumption.
- The RECD shall not lead to an increase of the DG set's noise emissions.

The RECD shall demonstrate to the Approval Authority. Any change instructed by approval authority shall be carryout by DG vendor without any additional cost RECD shall have good provision for a porthole/suitable arrangement just after tail pipe for emission monitoring at a later stage.

Method for measuring Smoke.

Method of smoke measurement shall be as per the guideline given in the applicable ISO-8178-3: Reciprocating internal combustion engines — Exhaust emission measurement — Part 3: Test procedure for measurement of exhaust gas smoke emissions from compression ignition engines using a filter type smoke meter.

Method of smoke measurement shall be the guideline given in the ISO 8178-9:2019 Reciprocating internal combustion engines — Exhaust emission measurement — Part 9: Test cycles and test procedures for measurement of exhaust gas smoke emissions from compression ignition engines using an opacimeter.

18. LIFT SPECIFICATIONS**Scope**

The scope of work covers design, manufacture, Supply to site, unloading and storage at site, installation, testing and commissioning, handing over of Lifts as detailed in this specification. The details of Passenger and Service Lifts are clearly defined in the below chapters.

General

- i. Items shall be executed as per BOQ, detailed specifications below and TN PWD specifications & CPWD General Specifications for Electrical works Part-III (Lift & Escalators) & NBC-2016 as amended up to date.
- ii. Contractor shall demonstrate testing of lifts as per standard practice of manufacture and as per TN PWD / C.P.W.D. specifications which is stringent.
- iii. Contractor shall obtain necessary license from Tamilnadu Government for operation of lifts (necessary fee for the same shall be paid by the Department).
- iv. Final finishing selection shall be as per instructions of Project officer In-charge.
- v. The lifts shall have brail button in each car as well as each landing, at each floor suitable audio and video signal shall be provided at lifts car arrival.
- vi. Lifts are to centrally monitored and switch on / off also necessary provision on BACnet / MODBUS may be provided on controller.

Detailed Specific Requirements for Lifts, please refer following:

(a) 20 Passenger Lift

SL. NO.	DESCRIPTION		REQUIRED TECHNICAL PARTICULARS
1	Type of lift	:	Passenger, Gearless & with Machine room
2	No. of lift required	:	8 Nos
3	Load, No. of persons	:	1360kg, 20 passengers
4	Rated speed	:	1.75mps
5	Travel in meter	:	As per Arch Drawing
6	Nos. of floor served	:	13 (Ground Floor to 12th Floor)
7	a) Inside size of lift well	:	2500mm W x 2400mm D
	b) Pit depth	:	As per Arch Drawing
	c) Head room	:	As per Arch Drawing
8	a) Clear inside size of lift car	:	"Max. Car sizes shall be as per NBC 2016"
	b) Landing door	:	1300mm W x 2300mm H, centre opening. As per OEM Standards
	c) Location of landing entrance in different floors	:	All floors on the same side
9	Dimension of lift machine room	:	MR (As per Arch Drawing)
10	Operation	:	10 Car group passenger lifts with DCS.
11	Lift car finishes	:	As per BOQ
12	False ceiling	:	As per BOQ
13	Flooring	:	As per BOQ
14	DCS- Operating Panel	:	Full DOAS system with 2 keypads in GF and 2 keypads in all other floors with voice announcement and braille with disabled friendly feature.

(b) Service Lift (Fire cum Service Lift)

SL. NO.	DESCRIPTION		REQUIRED TECHNICAL PARTICULARS
1	Type of lift	:	Service Lift, Gearless & with Machine room
2	No. of lift required	:	2 Nos
3	Load, No. of persons	:	1360kg, 20 passengers
4	Rated speed	:	1.5mps
5	Travel in meter	:	As per Arch Drawing
6	Nos. of floor served	:	14 (Ground Floor to 12 th Floor & Terrace)
7	Inside size of lift well	:	2500mm W x 2750mm D
	Pit depth	:	As per Arch Drawing
	Head room	:	As per Arch Drawing
8	a) Clear inside size of lift car	:	"Max. Car sizes shall be as per NBC 2016"
	b) Landing door	:	1300mm W x 2300mm HT, centre opening or As per OEM Standards.
	c) Location of landing entrance in different floors	:	All floors on the same side
9	Dimension of lift machine room	:	MR (As per Arch Drawing)
10	Operation	:	Simplex full collective
11	Lift car finishes	:	As per BOQ
12	False ceiling	:	As per BOQ
13	Flooring	:	As per BOQ
14	Car operating panel along with braille feature	:	Flushed COP with SS brush finish as per side walls .1 nos. COP shall be provided at left side of entrance door.
15	Hall Operating Panel & Lanterns		Stainless Steel Brushed Finished & with TFT LCD Display

Common Specification for All Lifts:			
1	Machine & Drive system	:	All machines shall be energy efficient permanent magnet gearless traction machines with ACVVVF drives and shall be full control closed loop. Every machine shall have the provision of manual rescue operation in addition to any electrical / battery back-up arrangement. Alternatively, the battery back-up device shall have a battery monitor that gives adequate audio / visual warning in case of inadequate charge. Drive system shall be ACVVVF with converter / inverter drives. Design unit to limit current, suppress noise and vibration transmission. The units shall be provided with internal heat sink cooling fans for the power drive portion of the converter panels.
2	Reduction channels	:	Vendor to include for reduction channels to resize shaft sizes
3	Car & Counterweight buffers	:	Car and counterweight buffers shall be of hydraulic type (Oil buffers) with necessary supporting channels and struts. The buffers shall be capable of with-standing twice the fully loaded car and two times the counterweight at contract speed + 15% and the fully compressed buffer top shall be not less than 1.2 meter from the bottom.
4	Handrails	:	All lifts shall be "disabled friendly" and shall comply with IS15330:2003 or the latest available amendment. The minimum requirements shall ensure braille (engraved) buttons, gong / chime, car annunciators, handrails etc.
5	Door operation	:	An VVVF electric door operator for opening and closing the door and the Hoist way door shall be provided which shall consist of a machine on the elevator car operating the car door when the car is stopping at a landing. The car door and hoist way door shall be mechanically connected and shall move simultaneously in opening and closing. The opening of car and hoist way doors shall be such that door shall start open just before the elevator approaches the landing meant for, so that by the time the elevator stops completely the car and hoist way doors be fully open with advance door operation (ADO) feature.

6	Hall button panel with braille feature	:	As per manufacturers standard options to choose from or as per Project Officer's in-charge instruction.
7	Hall position and direction indicator	:	As per manufacturers standard options to choose from or as per Project Officer's in-charge instruction
8	Hall button panel height (position)	:	At disabled friendly height
9	Battery Operated Emergency alarm	:	There shall be provided an alarm (solid state – siren type) unit operated by 7.2 Volts power pack consisting of rechargeable nickel – cadmium pencil cells which are trickle charged by a specified charging circuit. The unit gives a waxing and waning siren when alarm button in the car is pressed momentarily. The unit has a faceplate to match with the other car fixtures.
10	Battery Operated Emergency light	:	There shall be provided an emergency light unit using 7.2 volts power pack consisting of rechargeable nickel – cadmium pencil cells which are trickle charged by a special charger unit batter and miniature with a rectifier lamp. It will operate automatically in case of power failure. The unit is mounted in a metal box located above the car operating panel and will have a stainless-steel faceplate. A toggle switch is provided to put off the emergency light when main switch is put off preventing discharge of cells. Also, the charger circuit is so designed that after one hour of discharge, the discharge rate is drastically reduced to prevent complete discharge of the cells.
11	Voice annunciation system with floor announcing system	:	Required in Hindi and English language.
12	PA/music system interface	:	Required
13	Full length infra-red door protection	:	Doors shall have full length infra-red door sensors.
14	Fireman switch	:	All lifts shall be provided with fire man's switch. In case of fire, only fireman shall operate 'Fire Elevator'. In normal course, it may be used by other persons. There shall be provided a switch with glass cover at the ground floor which shall permit a fireman to break the glass cover and call the Elevator to ground floor by cancelling all car and landing calls. The Elevator shall then stop at the ground floor with the doors open to permit the fireman to have exclusive use of the Elevator without any interference from the landing calls.

15	3-way intercom (cabling in bidder's scope)	:	Intercoms shall always be provided for every unit. The intercoms shall be hands free 3-way communicator capable of connecting to building emergency room (Fire command centre at ground floor), Lift cabin and top floor control panel. Communication system for lift shall be connected to BMS Control Room, top floor control panel & Security Control for the building. All wiring within hoist way shall be by the Bidder.
16	Fire rating (for landing doors)	:	Landing doors in lift enclosures shall have a fire resistance of not less than two hours. Contractor to provide 2h fire rating certificate for lift doors.
17	Overload device	:	All lifts shall be provided with overload detector, warning indicator and buzzer. In case an overload is detected the car shall remain rest with the doors open. The elevator operation shall resume only upon removal of overload.
18	Home landing	:	Car shall automatically return to the designated home landing after answering the last pending call.
19	Automatic rescue device	:	Each lift shall be provided with its own battery-operated automatic rescue device. The automatic rescue device shall facilitate rescue on power failure. The equipment shall be so designed to execute at least 3 rescue operations between the floors with the maximum travel in a 60-minute period without recharging irrespective of load condition. The automatic rescue device shall execute a rescue operation if one, two or all phases of supply fail.
20	Provision for secure access control system interface	:	Secure access can be card readers, keypad readers or biometric fingerprint readers and shall be confirmed by employer/ Engineer in charge. The supplier shall readily interface with the Access Control Bidder at no extra cost.

21	BMS interface	:	BACNET/IP or MOD-BUS protocol in lift control panel to be integrated with BMS room 1. Status - Normal / Maintenance / Fireman operation 2. Direction of travel 3. Status of door - open / close 4. Car position 5. Passenger trapped alarm / intercom status and more requirements shall be notified later
22	Auto light and fan 'ON-OFF'	:	If the car is not used for a predetermined time, the light and fan inside the car shall automatically switch off. They shall be 'on' automatically when someone calls car from any landing.
23	Door nudging feature	:	Required
24	Car chime	:	All lifts shall be provided with arrival chimes notifying passengers visually and audibly of the arrival of an elevator in advance. The international norms shall be adhered to.
25	CCTV cabling interface	:	Required with CAT-6 cable.
26	Levelling accuracy +5mm	:	A micro-levelling feature shall be incorporated. Micro levelling shall correct for over-travel, under travel and rope stretch, within its zone independently of the operating device. Car levelling at each landing shall not exceed +/- 5 mm with or without load and down or upward travel.

TENDER DRAWINGS, DRAWINGS FOR APPROVAL & COMPLETION DRAWINGS

The drawings provided to the bidder with the tender documents give a general scheme of the system and are not meant to be the working drawings. The contractor shall furnish the shop drawings to be sent to the Engineer in charge, of all the equipment/ layouts after award of the contract and the same shall be approved by the Engineer in charge. No work shall be allowed to be executed without the approved shop drawings.

i) Tender Drawings

The drawings appended with the tender documents are intended to show the areas to be conditioned, space allotted for various equipment, tentative cable and pipe routes. The equipment offered shall be suitable for installation in the spaces shown in these drawings.

ii) Drawings for approval on award of the work

The contractor shall prepare & submit required sets of relevant drawings and get them approved from the Engineer-in-charge before the start of the work. The approval of drawings however does not absolve the contractor not to supply the equipment/ materials as per agreement, if there is any contradiction between the approved drawings and agreement.

Three sets of the relevant laminated drawings shall be submitted by the contractor while handing over the installation to the Department.

Documents to be furnished along with submission of tender document

i) Quality assurance plan for equipment to be submitted by the contractor.

Data to be furnished by the contractor after the award of contract and before installation

i) Schedule of drawings and documents to be submitted for review, approval and information with submission dates.

ii) Quality Assurance Plan (QAP).

iii) The drawing or documents shall include all design data and information furnished in data sheets.

iii) Procedure for performance testing.

iv) Test Certificates.

v) Erection, Start-up, Operation and maintenance manual with schedule, list of routine maintenance checks to be carried out, etc.

Documents to be furnished on completion of installation:

Required sets of the following documents shall be furnished to the department by the contractor on completion of work:

i) Completion drawings as mentioned above

ii) 3 sets of manufacturer's technical catalogues of all equipments and accessories.

iii) Operation and maintenance manual of all major equipments, detailing all Adjustments, operation and maintenance procedure, Mandatory & Recommended spares list for each equipment for 5 years.

19. ANNEXURE -1**HT / LT POWER CABLE SCHEDULE**

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
1	MAIN LT PANEL-1	APFCR PANEL-1	3.5 Cores 300 sqmm Al Arm	4
2	MAIN LT PANEL-1	RISING MAINS-1	3.5 Cores 400 sqmm Al Arm	6
3	MAIN LT PANEL-1	HVAC PANEL-1	3.5 Cores 400 sqmm Al Arm	6
4	MAIN LT PANEL-1	UTILITY PANEL	3.5 Cores 300 sqmm Al Arm	3
5	MAIN LT PANEL-1	FIRE PUMP PANEL	4 Cores 300 sqmm Al Arm. F.S	2
6	MAIN LT PANEL-1	UPS INPUT PANEL	3.5 Cores 240 sqmm Al Arm	1
7	MAIN LT PANEL-1	FIRE EMERGENCY PANEL	4 Cores 300 sqmm Al Arm. F.S	4
8	MAIN LT PANEL-1	APFCR PANEL-2	3.5 Cores 300 sqmm Al Arm	4
9	MAIN LT PANEL-2	APFCR PANEL-3	3.5 Cores 300 sqmm Al Arm	4
10	MAIN LT PANEL-2	RISING MAINS-2	3.5 Cores 400 sqmm Al Arm	6
11	MAIN LT PANEL-2	HVAC PANEL-2	3.5 Cores 400 sqmm Al Arm	6
12	MAIN LT PANEL-2	UPS INPUT PANEL	3.5 Cores 240 sqmm Al Arm	1
13	MAIN LT PANEL-2	EV CHARGING PANEL-1	3.5 Cores 300 sqmm Al Arm	1
14	MAIN LT PANEL-2	APFCR PANEL-4	3.5 Cores 300 sqmm Al Arm	4
15	MAIN LT PANEL-2	FIRE EMERGENCY PANEL	4 Cores 300 sqmm Al Arm. F.S	4
16	MAIN LT PANEL-2	UTILITY PANEL	3.5 Cores 400 sqmm Al Arm	2
17	MAIN LT PANEL-2	EV CHARGING PANEL-2	3.5 Cores 300 sqmm Al Arm	1
18	UTILITY PANEL	COMMON AREA LTG PANEL	3.5 Cores 50 sqmm Al Arm	1
19	UTILITY PANEL	COMMON AREA POWER PANEL	3.5 Cores 95 sqmm Al Arm	1
20	UTILITY PANEL	PHE PANEL	3.5 Cores 400 sqmm Al Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
21	UTILITY PANEL	STP	3.5 Cores 300 sqmm Al Arm	1
22	UTILITY PANEL	EXTERNAL LIGHTING DISTRIBUTION BOARD -1	4 Cores 16 sqmm Al Arm	1
23	UTILITY PANEL	EXTERNAL LIGHTING DISTRIBUTION BOARD -2	4 Cores 16 sqmm Al Arm	1
24	UTILITY PANEL	EXTERNAL LIGHTING DISTRIBUTION BOARD -3	4 Cores 16 sqmm Al Arm	1
25	UTILITY PANEL	EXTERNAL LIGHTING DISTRIBUTION BOARD -4	4 Cores 16 sqmm Al Arm	1
26	UTILITY PANEL	EXTERNAL VENTILATION PANEL (FOR STP & SWM)	3.5 Cores 50 sqmm Al Arm	1
27	UTILITY PANEL	SWM	4 Cores 16 sqmm Al Arm	1
28	UPS INPUT PANEL	100 A 4P MCCB	3.5 Cores 50 sqmm Al Arm	1
29		250 A 4P MCCB	3.5 Cores 95 sqmm Al Arm	1
30	100A4P MCCB	50kVA UPS-1	1 Cores 35 sqmm Cu flexible	4
31	50kVA UPS-1	UPS OUTPUT PANEL-1	1 Cores 35 sqmm Cu flexible	5
32	250A4P MCCB	100kVA UPS-1	1 Cores 95 sqmm Cu flexible	4
33	100kVA UPS-1	UPS OUTPUT PANEL-2	1 Cores 95 sqmm Cu flexible	5
34	UPS OUTPUT PANEL-1	G1-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
35	UPS OUTPUT PANEL-1	1F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
36	UPS OUTPUT PANEL-1	2F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
37	UPS OUTPUT PANEL-1	3F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
38	UPS OUTPUT PANEL-1	4F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
39	UPS OUTPUT PANEL-1	5F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
40	UPS OUTPUT PANEL-1	6F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
41	UPS OUTPUT PANEL-1	7F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
42	UPS OUTPUT PANEL-1	8F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
43	UPS OUTPUT PANEL-1	9F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
44	UPS OUTPUT PANEL-1	10F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
45	UPS OUTPUT PANEL-1	11F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
46	UPS OUTPUT PANEL-1	12F-ELDB1 (6W TPN)	4 Cores 6 sqmm Cu Arm	1
47	UPS OUTPUT PANEL-2	G1-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
48	UPS OUTPUT PANEL-2	1F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
49	UPS OUTPUT PANEL-2	2F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
50	UPS OUTPUT PANEL-2	3F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
51	UPS OUTPUT PANEL-2	4F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
52	UPS OUTPUT PANEL-2	5F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
53	UPS OUTPUT PANEL-2	6F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
54	UPS OUTPUT PANEL-2	7F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
55	UPS OUTPUT PANEL-2	8F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
56	UPS OUTPUT PANEL-2	9F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
57	UPS OUTPUT PANEL-2	10F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
58	UPS OUTPUT PANEL-2	11F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
59	UPS OUTPUT PANEL-2	12F-UPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
60	UPS OUTPUT PANEL-2	GF IBMS DB (FCC)	4 Cores 10 sqmm Cu Arm	1
61	UPS OUTPUT PANEL-2	2F IBMS DB	4 Cores 16 sqmm Cu Arm	1
62	COMMON AREA LTG PANEL	3F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
63	COMMON AREA LTG PANEL	4F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1
64	COMMON AREA LTG PANEL	5F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1
65	COMMON AREA LTG PANEL	6F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1
66	COMMON AREA LTG PANEL	7F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1
67	COMMON AREA LTG PANEL	8F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1
68	COMMON AREA LTG PANEL	9F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1
69	COMMON AREA LTG PANEL	10F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1
70	COMMON AREA LTG PANEL	11F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1
71	COMMON AREA LTG PANEL	12F-CLDB1 (8W TPN)	4 Cores 6 sqmm Cu Arm	1
72	COMMON AREA LTG PANEL	TERRACE-CLDB (8W TPN)	4 Cores 6 sqmm Cu Arm	1
73	COMMON AREA POWER PANEL	UGT-CPDB1 (12W SPN)	4 Cores 10 sqmm Cu Arm	1
74	COMMON AREA POWER PANEL	2F-CPDB2 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
75	COMMON AREA POWER PANEL	3F-CPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
76	COMMON AREA POWER PANEL	4F-CPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
77	COMMON AREA POWER PANEL	5F-CPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
78	COMMON AREA POWER PANEL	6F-CPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
79	COMMON AREA POWER PANEL	7F-CPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
80	COMMON AREA POWER PANEL	8F-CPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
81	COMMON AREA POWER PANEL	9F-CPDB1 (8W TPN)	4 Cores 10 sqmm Cu Arm	1
82	COMMON AREA POWER PANEL	10F-CPDB1 (8W TPN)	4 Cores 16 sqmm Cu Arm	1
83	COMMON AREA POWER PANEL	11F-CPDB1 (8W TPN)	4 Cores 16 sqmm Cu Arm	1
84	COMMON AREA POWER PANEL	12F-CPDB1 (8W TPN)	4 Cores 16 sqmm Cu Arm	1
85	COMMON AREA POWER PANEL	TERRACE-CPDB (8W TPN)	4 Cores 16 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
86	PHE PANEL	Domestic Water transfer pump Panel	4 Cores 25 sqmm Al Arm	1
87	PHE PANEL	Flushing Water transfer pump-(W)	4 Cores 25 sqmm Al Arm	1
88	PHE PANEL	HVAC Makeup Water transfer pump-(W)	4 Cores 25 sqmm Al Arm	1
89	PHE PANEL	Plant Room Dewatering Sump Pumps-Basement-01-(W)	4 Cores 16 sqmm Al Arm	1
90	PHE PANEL	Irrigation Pumps-Basement-01-(W)	4 Cores 16 sqmm Al Arm	1
91	PHE PANEL	Rainwater Overflow Pumps-Basement-01-(W)	4 Cores 25 sqmm Al Arm	1
92	PHE PANEL	Rainwater filter feed Pumps-Basement-01-(W)	4 Cores 16 sqmm Al Arm	1
93	PHE PANEL	Basement -02 Dewatering Sump Pumps (1W+1S SET)	4 Cores 10 sqmm Cu Arm	1
94	PHE PANEL	Domestic water terrace booster pump (1W+1S SET)	3 Cores 6 sqmm Cu Arm	1
95	PHE PANEL	HVAC Make up water booster pump (W)	3 Cores 10 sqmm Cu Arm	1
96	PHE PANEL	HVAC Make up water booster pump CL:5.5KW (S)	3 Cores 10 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
97	PHE PANEL	Sewage Sump Pumps	4 Cores 10 sqmm Cu Arm	1
98	PHE PANEL	Water Treatment plant for HVAC Makeup	4 Cores 16 sqmm Al Arm	1
99	HVAC PANEL-1	WATER COOLED CHILLER-1	3.5 Cores 300 sqmm Al Arm	2
100	HVAC PANEL-1	WATER COOLED CHILLER-2	3.5 Cores 300 sqmm Al Arm	2
101	HVAC PANEL-1	Pumps: Condenser Water (GPM)-(W)	3 Cores 95 sqmm Al Arm	2
102	HVAC PANEL-1	Pumps: Condenser Water (GPM)-(W)	3 Cores 95 sqmm Al Arm	2
103	HVAC PANEL-1	Pumps: Primary CHW (GPM)-(W)	3 Cores 95 sqmm Al Arm	2
104	HVAC PANEL-1	Pumps: Primary CHW (GPM)-(W)	3 Cores 95 sqmm Al Arm	2
105	HVAC PANEL-1	SECONDARY PUMP PANEL - 1	3.5 Cores 240 sqmm Al Arm	1
106	HVAC PANEL-1	COOLING TOWER FAN PANEL	3.5 Cores 240 sqmm Al Arm	1
107	HVAC PANEL-1	AIR COOLED CHILLER PANEL	3.5 Cores 300 sqmm Al Arm	2
108	HVAC PANEL-2	Pumps: Condenser Water (GPM)-(W)	3 Cores 95 sqmm Al Arm	2
109	HVAC PANEL-2	Pumps: Condenser Water (GPM)-(S)	3 Cores 95 sqmm Al Arm	2
110	HVAC PANEL-2	Pumps: Primary CHW (GPM)-(W)	3 Cores 95 sqmm Al Arm	2

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
111	HVAC PANEL-2	Pumps: Primary CHW (GPM)-(S)	3 Cores 95 sqmm Al Arm	2
112	HVAC PANEL-2	WATER COOLED CHILLER-3-(W)	3.5 Cores 300 sqmm Al Arm	2
113	HVAC PANEL-2	WATER COOLED CHILLER-3-(S)	3.5 Cores 300 sqmm Al Arm	2
114	HVAC PANEL-2	AIR COOLED CHILLER PANEL	3.5 Cores 300 sqmm Al Arm	2
115	HVAC PANEL-2	COOLING TOWER FAN PANEL	3.5 Cores 240 sqmm Al Arm	1
116	HVAC PANEL-2	GROUND HVAC PANEL	3.5 Cores 240 sqmm Al Arm	1
117	HVAC PANEL-2	TERRACE VENTILATION PANEL	3.5 Cores 400 sqmm Al Arm	1
118	COOLING TOWER FAN PANEL	Cooling Tower Fan Panel-1	4 Cores 16 sqmm Al Arm	1
119	COOLING TOWER FAN PANEL	Cooling Tower Fan Panel-1	4 Cores 16 sqmm Al Arm	1
120	COOLING TOWER FAN PANEL	Cooling Tower Fan Panel-2	4 Cores 16 sqmm Al Arm	1
121	COOLING TOWER FAN PANEL	Cooling Tower Fan Panel-2	4 Cores 16 sqmm Al Arm	1
122	COOLING TOWER FAN PANEL	Cooling Tower Fan Panel-3	4 Cores 16 sqmm Al Arm	1
123	COOLING TOWER FAN PANEL	Cooling Tower Fan Panel-3	4 Cores 16 sqmm Al Arm	1
124	COOLING TOWER FAN PANEL	Cooling Tower Fan Panel-4	4 Cores 16 sqmm Al Arm	1
125	COOLING TOWER FAN PANEL	Cooling Tower Fan Panel-4	4 Cores 16 sqmm Al Arm	1
126	AIR COOLED CHILLER PANEL	AIR COOLED CHILLER-(W)	3.5 Cores 150 sqmm Al Arm	2
127	AIR COOLED CHILLER PANEL	AIR COOLED CHILLER-(S)	3.5 Cores 150 sqmm Al Arm	2
128	AIR COOLED CHILLER PANEL	Pumps: Primary Water (GPM)-(W)	3 Cores 10 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
129	AIR COOLED CHILLER PANEL	Pumps: Primary Water (GPM)-(W)	3 Cores 10 sqmm Cu Arm	1
130	AIR COOLED CHILLER PANEL	Pumps: Secondary Water (GPM)	3.5 Cores 35 sqmm Al Arm	1
131	GROUND HVAC PANEL	Plant Room Supply Air Fan	3 Cores 6 sqmm Cu Arm	1
132	GROUND HVAC PANEL	Plant Room Supply Air Fan	3 Cores 6 sqmm Cu Arm	1
133	GROUND HVAC PANEL	Pressurization Unit	3 Cores 6 sqmm Cu Arm	1
134	GROUND HVAC PANEL	Condenser Tube CLEANING	3 Cores 6 sqmm Cu Arm	1
135	GROUND HVAC PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
136	GROUND HVAC PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
137	GROUND HVAC PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
138	GROUND HVAC PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
139	GROUND HVAC PANEL	Transfer Room/Panel Supply Air Fan	3 Cores 6 sqmm Cu Arm	1
140	GROUND HVAC PANEL	Transfer Room/Panel Exhaust Air Fan	3 Cores 6 sqmm Cu Arm	1
141	GROUND HVAC PANEL	DG room Ventilation	4 Cores 25 sqmm Al Arm	1
142	GROUND HVAC PANEL	DG room Ventilation	4 Cores 25 sqmm Al Arm	1
143	GROUND HVAC PANEL	DG room Ventilation 3&4	4 Cores 25 sqmm Al Arm	1
144	GROUND HVAC PANEL	DG room Ventilation 5&6	4 Cores 25 sqmm Al Arm	1
145	GROUND HVAC PANEL	Transformer Ventilation	3 Cores 6 sqmm Cu Arm	1
146	GROUND HVAC PANEL	Transformer Ventilation	3 Cores 6 sqmm Cu Arm	1
147	GROUND HVAC PANEL	Transformer Ventilation	3 Cores 6 sqmm Cu Arm	1
148	GROUND HVAC PANEL	Transformer Ventilation	3 Cores 6 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
149	GROUND HVAC PANEL	HVAC DB (4WTPN)	4 Cores 6 sqmm Cu Arm	1
150	GROUND HVAC PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
151	TERRACE VENTILATION PANEL	TFA-HRW AHU -Supply	4 Cores 16 sqmm Al Arm	1
152	TERRACE VENTILATION PANEL	TFA-HRW AHU -Supply	4 Cores 16 sqmm Al Arm	1
153	TERRACE VENTILATION PANEL	TFA-HRW AHU -Supply	4 Cores 16 sqmm Al Arm	1
154	TERRACE VENTILATION PANEL	TFA-HRW AHU -Supply	4 Cores 16 sqmm Al Arm	1
155	TERRACE VENTILATION PANEL	TFA-HRW AHU -Supply	4 Cores 16 sqmm Al Arm	1
156	TERRACE VENTILATION PANEL	TFA-HRW AHU -Supply	4 Cores 16 sqmm Al Arm	1
157	TERRACE VENTILATION PANEL	TFA-HRW AHU -Exhaust	4 Cores 6 sqmm Cu Arm	1
158	TERRACE VENTILATION PANEL	TFA-HRW AHU -Exhaust	4 Cores 6 sqmm Cu Arm	1
159	TERRACE VENTILATION PANEL	TFA-HRW AHU -Exhaust	4 Cores 6 sqmm Cu Arm	1
160	TERRACE VENTILATION PANEL	TFA-HRW AHU -Exhaust	4 Cores 6 sqmm Cu Arm	1
161	TERRACE VENTILATION PANEL	Toilet Exhaust Gr	3 Cores 6 sqmm Cu Arm	1
162	TERRACE VENTILATION PANEL	Toilet Exhaust Gr	3 Cores 6 sqmm Cu Arm	1
163	TERRACE VENTILATION PANEL	Toilet Exhaust Gr	3 Cores 6 sqmm Cu Arm	1
164	TERRACE VENTILATION PANEL	Toilet Exhaust Gr	3 Cores 6 sqmm Cu Arm	1
165	TERRACE VENTILATION PANEL	Electrical Room Exhaust	3 Cores 6 sqmm Cu Arm	1
166	TERRACE VENTILATION PANEL	Kitchen SISW Fan	4 Cores 25 sqmm Al Arm	1
167	TERRACE VENTILATION PANEL	Scrubber	4 Cores 6 sqmm Cu Arm	1
168	TERRACE VENTILATION PANEL	Scrubber	4 Cores 6 sqmm Cu Arm	1
169	TERRACE VENTILATION PANEL	Scrubber	4 Cores 6 sqmm Cu Arm	1
170	TERRACE VENTILATION PANEL	Kitchen SISW supply Fan	4 Cores 6 sqmm Cu Arm	1
171	TERRACE VENTILATION PANEL	HVAC DB (4WTPN)	4 Cores 6 sqmm Cu Arm	1
172	FIRE EMERGENCY PANEL	ELEVATOR PANEL	4 Cores 300 sqmm Al Arm. F.S	2

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
173	FIRE EMERGENCY PANEL	FIRE PUMP PANEL	4 Cores 300 sqmm Al Arm. F.S	2
174	FIRE EMERGENCY PANEL	PRESSURIZATION PANEL	4 Cores 120 sqmm Al Arm FS	2
175	ELEVATOR PANEL	LIFT CONTROL PANEL 01	4CX16 sqmm Cu FS. CABLE	1
176	ELEVATOR PANEL	LIFT CONTROL PANEL 02	4CX16 sqmm Cu FS. CABLE	1
177	ELEVATOR PANEL	LIFT CONTROL PANEL 03	4CX16 sqmm Cu FS. CABLE	1
178	ELEVATOR PANEL	LIFT CONTROL PANEL 04	4CX16 sqmm Cu FS. CABLE	1
179	ELEVATOR PANEL	LIFT CONTROL PANEL 05	4CX16 sqmm Cu FS. CABLE	1
180	ELEVATOR PANEL	LIFT CONTROL PANEL 06	4CX16 sqmm Cu FS. CABLE	1
181	ELEVATOR PANEL	LIFT CONTROL PANEL 07	4CX16 sqmm Cu FS. CABLE	1
182	ELEVATOR PANEL	LIFT CONTROL PANEL 08	4CX16 sqmm Cu FS. CABLE	1
183	ELEVATOR PANEL	LIFT CONTROL PANEL 09	4CX16 sqmm Cu FS. CABLE	1
184	ELEVATOR PANEL	LIFT CONTROL PANEL 10	4CX16 sqmm Cu FS. CABLE	1
185	ELEVATOR PANEL	LIFT CONTROL PANEL 11	4CX16 sqmm Cu FS. CABLE	1
186	ELEVATOR PANEL	LIFT CONTROL PANEL 12	4CX16 sqmm Cu FS. CABLE	1
187	LIFT CONTROL PANEL	LIFT MOTOR 1	4CX10 sqmm Cu FS. CABLE	1
188	LIFT CONTROL PANEL	LIFT MOTOR 2	4CX10 sqmm Cu FS. CABLE	1
189	LIFT CONTROL PANEL	LIFT MOTOR 3	4CX10 sqmm Cu FS. CABLE	1
190	LIFT CONTROL PANEL	LIFT MOTOR 4	4CX10 sqmm Cu FS. CABLE	1
191	LIFT CONTROL PANEL	LIFT MOTOR 5	4CX10 sqmm Cu FS. CABLE	1
192	LIFT CONTROL PANEL	LIFT MOTOR 6	4CX10 sqmm Cu FS. CABLE	1
193	LIFT CONTROL PANEL	LIFT MOTOR 7	4CX10 sqmm Cu FS. CABLE	1
194	LIFT CONTROL PANEL	LIFT MOTOR 8	4CX10 sqmm Cu FS. CABLE	1
195	LIFT CONTROL PANEL	LIFT MOTOR 9	4CX10 sqmm Cu FS. CABLE	1
196	LIFT CONTROL PANEL	LIFT MOTOR 10	4CX10 sqmm Cu FS. CABLE	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
197	LIFT CONTROL PANEL	LIFT MOTOR 11	4CX10 sqmm Cu FS. CABLE	1
198	LIFT CONTROL PANEL	LIFT MOTOR 12	4CX10 sqmm Cu FS. CABLE	1
199	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
200	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
201	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
202	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
203	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
204	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
205	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
206	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
207	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
208	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
209	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
210	PRESSURIZATION PANEL	Liftwell Pressurization	3CX6 sqmm Cu FS. CABLE	1
211				
212				
213	PRESSURIZATION PANEL	Staircase Pressurization	3CX6 sqmm Cu FS. CABLE	1
214	PRESSURIZATION PANEL	Staircase Pressurization	3CX6 sqmm Cu FS. CABLE	1
215	PRESSURIZATION PANEL	Lift Lobby Pressurization	3CX6 sqmm Cu FS. CABLE	1
216	PRESSURIZATION PANEL	Lift Lobby Pressurization	3CX6 sqmm Cu FS. CABLE	1
217	PRESSURIZATION PANEL	Lift Lobby Pressurization	3CX6 sqmm Cu FS. CABLE	1
218	PRESSURIZATION PANEL	Lift Lobby Pressurization	3CX6 sqmm Cu FS. CABLE	1
219	PRESSURIZATION PANEL	Main Lobby Smoke Exhaust	3CX6 sqmm Cu FS. CABLE	1
220	PRESSURIZATION PANEL	Multipurpose Smoke Exhaust	3CX6 sqmm Cu FS. CABLE	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
221	PRESSURIZATION PANEL	Multipurpose Smoke Make Up	3CX6 sqmm Cu FS. CABLE	1
222	RISING MAINS-1	GF MAIN POWER PANEL	3.5 Cores 50 sqmm Al Arm	1
223	RISING MAINS-2	GF MAIN POWER PANEL	3.5 Cores 50 sqmm Al Arm	1
224	GF MAIN POWER PANEL	GF-LDB1	4 Cores 6 sqmm Cu Arm	1
225	GF MAIN POWER PANEL	GF-LDB2	4 Cores 6 sqmm Cu Arm	1
226	GF MAIN POWER PANEL	GF-PDB1	4 Cores 6 sqmm Cu Arm	1
227	GF MAIN POWER PANEL	GF-PDB2	4 Cores 6 sqmm Cu Arm	1
228	RISING MAINS-1	1F MAIN POWER PANEL	3.5 Cores 240 sqmm Al Arm	2
229	RISING MAINS-2	1F MAIN POWER PANEL	3.5 Cores 240 sqmm Al Arm	2
230	1F MAIN POWER PANEL	1F-LDB1	4 Cores 6 sqmm Cu Arm	1
231	1F MAIN POWER PANEL	1F-PDB1	4 Cores 10 sqmm Cu Arm	1
232	1F MAIN POWER PANEL	HVAC DB1 (4W TPN)	4 Cores 6 sqmm Cu Arm	1
233	1F MAIN POWER PANEL	PAC UNIT (W)	4 Cores 10 sqmm Cu Arm	1
234	1F MAIN POWER PANEL	PAC UNIT (W)	4 Cores 10 sqmm Cu Arm	1
235	1F MAIN POWER PANEL	LT PANEL ROOM FAN-1 (W)	3 Cores 6 sqmm Cu Arm	1
236	1F MAIN POWER PANEL	LT PANEL ROOM FAN-2 (W)	3 Cores 6 sqmm Cu Arm	1
237	1F MAIN POWER PANEL	LT PANEL ROOM FAN-3 (W)	3 Cores 6 sqmm Cu Arm	1
238	1F MAIN POWER PANEL	LT PANEL ROOM FAN-4 (W)	3 Cores 6 sqmm Cu Arm	1
239	1F MAIN POWER PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
240	1F MAIN POWER PANEL	1F CAFÉ PANEL	3.5 Cores 120 sqmm Al Arm	2
241	1F CAFÉ PANEL	1F-CAFE LDB	4 Cores 6 sqmm Cu Arm	1
242	1F CAFÉ PANEL	1F-CAFE PDB1	4 Cores 10 sqmm Cu Arm	1
243	1F CAFÉ PANEL	1F-CAFE PDB2	4 Cores 10 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
244	1F CAFÉ PANEL	CSU 1	4 Cores 6 sqmm Cu Arm	1
245	1F CAFÉ PANEL	CSU 2	4 Cores 6 sqmm Cu Arm	1
246	1F CAFÉ PANEL	CSU 3	4 Cores 6 sqmm Cu Arm	1
247	1F CAFÉ PANEL	CSU 4	4 Cores 6 sqmm Cu Arm	1
248	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 1	4 Cores 10 sqmm Cu Arm	1
249	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 2	4 Cores 10 sqmm Cu Arm	1
250	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 3	4 Cores 10 sqmm Cu Arm	1
251	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 4	4 Cores 10 sqmm Cu Arm	1
252	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 5	4 Cores 10 sqmm Cu Arm	1
253	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 6	4 Cores 10 sqmm Cu Arm	1
254	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 7	4 Cores 10 sqmm Cu Arm	1
255	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 8	4 Cores 10 sqmm Cu Arm	1
256	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 9	4 Cores 10 sqmm Cu Arm	1
257	1F CAFÉ PANEL	VTPN DB CAFÉ COUNTER 10	4 Cores 10 sqmm Cu Arm	1
258	1F CAFÉ PANEL	KITCHEN EQUIPMENT DB	3.5 Cores 50 sqmm Al Arm	1
259	1F CAFÉ PANEL	DISH WASHER -1	3.5 Cores 50 sqmm Al Arm	1
260	1F CAFÉ PANEL	DISH WASHER -2	3.5 Cores 50 sqmm Al Arm	1
261	RISING MAINS-1	2F MAIN POWER PANEL	3.5 Cores 185 sqmm Al Arm	1
262	RISING MAINS-2	2F MAIN POWER PANEL	3.5 Cores 185 sqmm Al Arm	1
263	2F MAIN POWER PANEL	2F-LDB1	4 Cores 6 sqmm Cu Arm	1
264	2F MAIN POWER PANEL	2F-LDB2	4 Cores 6 sqmm Cu Arm	1
265	2F MAIN POWER PANEL	2F-PDB1	4 Cores 10 sqmm Cu Arm	1
266	2F MAIN POWER PANEL	2F-PDB2	4 Cores 10 sqmm Cu Arm	1
267	2F MAIN POWER PANEL	2FPDB CAFÉ	4 Cores 10 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
268	2F MAIN POWER PANEL	2F HVAC POWER PANEL	3.5 Cores 50 sqmm Al Arm	1
269	2F HVAC POWER PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
270	2F HVAC POWER PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
271	2F HVAC POWER PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
272	2F HVAC POWER PANEL	CSU	4 Cores 6 sqmm Cu Arm	1
273	2F HVAC POWER PANEL	HVAC DB1 (4W TPN)	4 Cores 6 sqmm Cu Arm	1
274	2F HVAC POWER PANEL	CASSETTE UNIT	4 Cores 10 sqmm Cu Arm	1
275	2F HVAC POWER PANEL	PAC UNIT (W)	4 Cores 10 sqmm Cu Arm	1
276	2F HVAC POWER PANEL	PAC UNIT (W)	4 Cores 10 sqmm Cu Arm	1
277	2F HVAC POWER PANEL	CSU CAFETERIA	4 Cores 6 sqmm Cu Arm	1
278	2FPDB CAFÉ	CSU	4 Cores 6 sqmm Cu Arm	1
279	2FPDB CAFÉ	CSU	4 Cores 6 sqmm Cu Arm	1
280	2FPDB CAFÉ	CSU	4 Cores 6 sqmm Cu Arm	1
281	RISING MAINS-1	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	3.5 Cores 400 sqmm Al Arm	1
282	RISING MAINS-2	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	3.5 Cores 400 sqmm Al Arm	1
283	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	TO TENANT-1 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
284	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	TO TENANT-2 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
285	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	TO TENANT-3 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
286	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	TO TENANT-4 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
287	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	TO TENANT-5 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
288	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	TO TENANT-6 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
289	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	TO TENANT-7 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
290	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	TO TENANT-8 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
291	TYPICAL FLOOR MAIN POWER PANEL (3F , 4F , 5F, 6F , 7F)	3F HVAC POWER PANEL	3.5 Cores 120 sqmm Al Arm	1
292	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	AHU	4 Cores 10 sqmm Cu Arm	1
293	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	AHU	4 Cores 10 sqmm Cu Arm	1
294	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	AHU	4 Cores 10 sqmm Cu Arm	1
295	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	AHU	4 Cores 10 sqmm Cu Arm	1
296	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	AHU	4 Cores 10 sqmm Cu Arm	1
297	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	AHU	4 Cores 10 sqmm Cu Arm	1
298	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	AHU	4 Cores 10 sqmm Cu Arm	1
299	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	AHU	4 Cores 10 sqmm Cu Arm	1
300	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	HVAC DB1 (4W TPN)	4 Cores 10 sqmm Cu Arm	1
301	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	Equipment for Critical Space	4 Cores 10 sqmm Cu Arm	1
302	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	Equipment for Critical Space	4 Cores 10 sqmm Cu Arm	1
303	HVAC POWER PANEL (3F , 4F , 5F, 6F , 7F)	CSU	4 Cores 6 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
304	RISING MAINS-1	TYPICAL FLOOR MAIN POWER PANEL (8F , 9F ,10F ,11F, 12F)	3.5 Cores 400 sqmm Al Arm	1
305	RISING MAINS-2	TYPICAL FLOOR MAIN POWER PANEL (8F , 9F ,10F ,11F, 12F)	3.5 Cores 400 sqmm Al Arm	1
306	TYPICAL FLOOR MAIN POWER PANEL (8F , 9F ,10F ,11F, 12F)	TO TENANT-1 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
307	TYPICAL FLOOR MAIN POWER PANEL (8F , 9F ,10F ,11F, 12F)	TO TENANT-2 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
308	TYPICAL FLOOR MAIN POWER PANEL (8F , 9F ,10F ,11F, 12F)	TO TENANT-3 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
309	TYPICAL FLOOR MAIN POWER PANEL (8F , 9F ,10F ,11F, 12F)	TO TENANT-4 (4 WAY V TPN DB)	3.5 Cores 50 sqmm Al Arm	1
310	TYPICAL FLOOR MAIN POWER PANEL (8F , 9F ,10F ,11F, 12F)	REFUGE LDB	4 Cores 6 sqmm Cu Arm	1
311	TYPICAL FLOOR MAIN POWER PANEL (8F , 9F ,10F ,11F, 12F)	REFUGE PDB	4 Cores 6 sqmm Cu Arm	1
312	TYPICAL FLOOR MAIN POWER PANEL (8F , 9F ,10F ,11F, 12F)	3F HVAC POWER PANEL	3.5 Cores 50 sqmm Al Arm	1
313	HVAC POWER PANEL (8F , 9F ,10F ,11F, 12F)	AHU	4 Cores 10 sqmm Cu Arm	1
314	HVAC POWER PANEL (8F , 9F ,10F ,11F, 12F)	AHU	4 Cores 10 sqmm Cu Arm	1
315	HVAC POWER PANEL (8F , 9F ,10F ,11F, 12F)	AHU	4 Cores 10 sqmm Cu Arm	1
316	HVAC POWER PANEL (8F , 9F ,10F ,11F, 12F)	AHU	4 Cores 10 sqmm Cu Arm	1
317	HVAC POWER PANEL (8F , 9F ,10F ,11F, 12F)	HVAC DB1 (4W TPN)	4 Cores 6 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
318	SOLAR PANEL	UTILITY PANEL	3.5 Cores 120 sqmm Al Arm	1
319	EV CHARGING PANEL -1	4W EV CHARGER -1	3 Cores 10 sqmm Cu Arm	1
320	EV CHARGING PANEL -1	4W EV CHARGER -2	3 Cores 10 sqmm Cu Arm	1
321	EV CHARGING PANEL -1	4W EV CHARGER -3	3 Cores 10 sqmm Cu Arm	1
322	EV CHARGING PANEL -1	4W EV CHARGER -4	3 Cores 10 sqmm Cu Arm	1
323	EV CHARGING PANEL -1	4W EV CHARGER -5	3 Cores 10 sqmm Cu Arm	1
324	EV CHARGING PANEL -1	E V CHARGING PANEL 2	3.5 Cores 95 sqmm Al Arm	1
325	EV CHARGING PANEL -1	4W EV CHARGER -6	3 Cores 10 sqmm Cu Arm	1
326	EV CHARGING PANEL -1	4W EV CHARGER -7	3 Cores 10 sqmm Cu Arm	1
327	EV CHARGING PANEL -1	4W EV CHARGER -8	3 Cores 10 sqmm Cu Arm	1
328	EV CHARGING PANEL -1	4W EV CHARGER -9	3 Cores 10 sqmm Cu Arm	1
329	EV CHARGING PANEL -1	4W EV CHARGER -10	3 Cores 10 sqmm Cu Arm	1
330	EV CHARGING PANEL -2	2W EV CHARGER 1	4 Cores 10 sqmm Cu Arm	1
331	EV CHARGING PANEL -2	2W EV CHARGER 2	4 Cores 10 sqmm Cu Arm	1
332	EV CHARGING PANEL -2	2W EV CHARGER 3	4 Cores 10 sqmm Cu Arm	1
333	EV CHARGING PANEL -2	2W EV CHARGER 4	4 Cores 10 sqmm Cu Arm	1
334	EV CHARGING PANEL -2	2W EV CHARGER 5	4 Cores 10 sqmm Cu Arm	1
335	EV CHARGING PANEL -2	2W EV CHARGER 6	4 Cores 10 sqmm Cu Arm	1
336	EV CHARGING PANEL -2	2W EV CHARGER 7	4 Cores 10 sqmm Cu Arm	1
337	EV CHARGING PANEL -2	2W EV CHARGER 8	4 Cores 10 sqmm Cu Arm	1
338	EV CHARGING PANEL -2	2W EV CHARGER 9	4 Cores 10 sqmm Cu Arm	1
339	EV CHARGING PANEL -2	2W EV CHARGER 10	4 Cores 10 sqmm Cu Arm	1
340	EV CHARGING PANEL -2	2W EV CHARGER 11	4 Cores 10 sqmm Cu Arm	1
341	EV CHARGING PANEL -2	2W EV CHARGER 12	4 Cores 10 sqmm Cu Arm	1

SR.	FROM	TO	SIZE OF POWER CABLE	NO. OF RUNS
342	EV CHARGING PANEL -2	2W EV CHARGER 13	4 Cores 10 sqmm Cu Arm	1
343	EV CHARGING PANEL -2	2W EV CHARGER 14	4 Cores 10 sqmm Cu Arm	1
344	EV CHARGING PANEL -2	2W EV CHARGER 15	4 Cores 10 sqmm Cu Arm	1
345	EV CHARGING PANEL -2	2W EV CHARGER 16	4 Cores 10 sqmm Cu Arm	1
346	EV CHARGING PANEL -2	2W EV CHARGER 17	4 Cores 10 sqmm Cu Arm	1
347	SEC PUMP PANEL -1	PUMP -1	3 Cores 95 sqmm Al Arm	2
348	SEC PUMP PANEL -1	PUMP -2	3 Cores 95 sqmm Al Arm	2
349	SEC PUMP PANEL -1	PUMP -3	3 Cores 95 sqmm Al Arm	2
350	SEC PUMP PANEL -1	PUMP -4	3 Cores 95 sqmm Al Arm	2
351	AIR COOLED CHILLER PANEL	PUMP -1	3 Cores 16 sqmm Cu Arm	1
352	AIR COOLED CHILLER PANEL	PUMP -2	3 Cores 16 sqmm Cu Arm	1
353	EXTERNAL LIGHTING DISTRIBUTION BOARD -1	Lgt CKT-1	4 Cores 6 sqmm Cu Arm	1
354	EXTERNAL LIGHTING DISTRIBUTION BOARD -1	Lgt CKT-2	4 Cores 6 sqmm Cu Arm	1
355	EXTERNAL LIGHTING DISTRIBUTION BOARD -1	Lgt CKT-3	4 Cores 6 sqmm Cu Arm	1
356	EXTERNAL LIGHTING DISTRIBUTION BOARD -1	Lgt CKT-4	4 Cores 6 sqmm Cu Arm	1
357	EXTERNAL LIGHTING DISTRIBUTION BOARD -2	Lgt CKT-1	3 Cores 4 sqmm Cu Arm	1
358	EXTERNAL LIGHTING DISTRIBUTION BOARD -2	Lgt CKT-2	3 Cores 4 sqmm Cu Arm	1
359	EXTERNAL LIGHTING DISTRIBUTION BOARD -2	Lgt CKT-3	3 Cores 4 sqmm Cu Arm	1
360	EXTERNAL LIGHTING DISTRIBUTION BOARD -2	Lgt CKT-4	3 Cores 4 sqmm Cu Arm	1
361	CAFE VTPN DB	TO 32A SOCKET	3 Cores 4 sqmm Cu Arm	1
362	CAFE VTPN DB	TO 32A SOCKET	3 Cores 4 sqmm Cu Arm	1
363	CAFE VTPN DB	TO 32A SOCKET	3 Cores 4 sqmm Cu Arm	1
364	CAFE VTPN DB	TO 32A SOCKET	3 Cores 4 sqmm Cu Arm	1
365	EXTERNAL SWM VENTILATION PANEL	ELECTRICAL PANEL HSD AREA	3 Cores 50 sqmm Al Arm	1

DATASHEET – ELECTRICAL WORKS
CONTENTS

A.	DATA SHEET FOR LT POWER CABLES	2
B.	DATA SHEET FOR LT FIRE SURVIVAL (FS) CABLES	4
C.	DATA SHEET FOR LT CONTROL CABLES	6
D.	DATA SHEET FOR DISTRIBUTION TRANSFORMER	8
E.	DATA SHEET FOR HT CABLES	10
F.	DATA SHEET FOR BUSBAR TRUNKING/BUSDUCTS	12
G.	DATA SHEET FOR HT PANELS	17
H.	DATA SHEET FOR LT PANELS	21
I.	DATA SHEET FOR APFCR PANELS	27
J.	DATA SHEET FOR VFD	29
K.	DATA SHEET FOR UPS	31
L.	DATA SHEET FOR DG SETS.....	33

A. DATA SHEET FOR LT POWER CABLES

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1.0	SYSTEM DATA		
1.1	System Voltage with voltage variation	V	415V
1.2	Short circuit for 1 Sec.	KA (rms)	50kA
1.3	Design ambient temperature of cable	deg. C	45
1.4	Laying (underground/air/duct/trench)		air/duct/trench
2.0	<u>CABLE DATA</u>		
2.1	Type of Cable(HV Power/LV Power/Control/Instrumentation/Telecommunication)		LV POWER
2.2	Rated voltage of cable (U ₀ /U)	kV	1.1
2.3	Core (Multi/single)		REFER BOQ
2.4	Conductor (Aluminium/Copper)		REFER BOQ
2.4.1	Conductor (stranded/solid)		REFER BOQ
2.4.2	Conductor Screen required	Yes/No	NO
2.4.3	Effective cross sectional area of conductor	sq.mm.	REFER BOQ
2.5	Insulation material (XLPE/PVC/PTFE/etc.)		XLPE
2.5.1	If PVC, type of insulation (Type A or C)		
2.5.2	Insulation screen required	Yes/No	NO
2.6	Inner Sheath required	Yes/No	NO
2.6.1	Inner sheath material and type (A or C)		ST2
2.7	Armour Required	Yes/No	YES
2.7.1	Armour Type and material		GI STRIP & ROUND FOR SMALLER CABLES
2.7	Outer sheath Required	Yes/No	YES
2.7.1	Outer Sheath material and type (ST 1 or ST 2)		ST2
2.8	Cable Drum Type (Wooden/Steel)		WOODEN

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
2.8.1	Drum length required	m	AS PER SITE REQUIREMENT. NO JOINTING KIT IS ALLOWED
2.8.2	Cable quantity tolerance		+5%
3.0	SPECIFIC REQUIREMENT		
3.1	Outer Sheath type (Fire Survival (FS) /Flame Retardant Low Smoke (FRLS)/ FRLSZH		FRLS
3.2	Fire Protective paint required	Yes/No	NO
3.3	Instrumentation Cable type(Pair/Triad/Quad/ Quintuple)		

B. DATA SHEET FOR LT FIRE SURVIVAL (FS) CABLES

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1.0	SYSTEM DATA		
1.1	System Voltage with voltage variation	V	415V
1.2	Short circuit for 1 Sec.	KA (rms)	50kA
1.3	Design ambient temperature of cable	deg. C	45
1.4	Laying (underground/air/duct/trench)		air/duct/trench
2.0	<u>CABLE DATA</u>		
2.1	Type of Cable(HV Power/LV Power/Control/Instrumentation/Telecommunication)		LV POWER
2.2	Rated voltage of cable (U ₀ /U)	kV	1.1
2.3	Core (Multi/single)		REFER BOQ
2.4	Conductor (Aluminium/Copper)		REFER BOQ
2.4.1	Conductor (stranded/solid)		REFER BOQ
2.4.2	Conductor Screen required	Yes/No	NO
2.4.3	Effective cross-sectional area of conductor	sq.mm.	REFER BOQ
2.5	Insulation material (XLPE/PVC/PTFE/etc.)		XLPE
2.5.1	If PVC, type of insulation (Type A or C)		
2.5.2	Insulation screen required	Yes/No	NO
2.6	Inner Sheath required	Yes/No	NO
2.6.1	Inner sheath material and type (A or C)		ST2
2.7	Armour Required	Yes/No	YES
2.7.1	Armour Type and material		GI STRIP & ROUND FOR SMALLER CABLES
2.7	Outer sheath Required	Yes/No	YES
2.7.1	Outer Sheath material and type (ST 1 or ST 2)		ST2
2.8	Cable Drum Type (Wooden/Steel)		WOODEN
2.8.1	Drum length required	m	AS PER SITE REQUIREMENT. NO

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
			JOINTING KIT IS ALLOWED
2.8.2	Cable quantity tolerance		+5%
3.0	SPECIFIC REQUIREMENT		
3.1	Outer Sheath type (Fire Survival (FS) /Flame Retardant Low Smoke (FRLS)/ FRLSZH		FS
3.2	Fire Protective paint required	Yes/No	NO
3.3	Instrumentation Cable type(Pair/Triad/Quad/ Quintuple)		

C. DATA SHEET FOR LT CONTROL CABLES

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1.0	SYSTEM DATA		
1.1	System Voltage with voltage variation	V	415V
1.2	Short circuit for 1 Sec.	KA (rms)	50kA
1.3	Design ambient temperature of cable	deg. C	45
1.4	Laying (underground/air/duct/trench)		air/duct/trench
2.0	<u>CABLE DATA</u>		
2.1	Type of Cable(HV Power/LV Power/Control/Instrumentation/Telecommunication)		LV POWER
2.2	Rated voltage of cable (U ₀ /U)	kV	1.1
2.3	Core (Multi/single)		REFER BOQ
2.4	Conductor (Aluminium/Copper)		Copper
2.4.1	Conductor (stranded/solid)		stranded
2.4.2	Conductor Screen required	Yes/No	No
2.4.3	Effective cross sectional area of conductor	sq.mm.	REFER BOQ
2.5	Insulation material (XLPE/PVC/PTFE/etc.)		PVC
2.5.1	If PVC, type of insulation (Type A or C)		
2.5.2	Insulation screen required	Yes/No	NO
2.6	Inner Sheath required	Yes/No	NO
2.6.1	Inner sheath material and type (A or C)		ST2
2.7	Armour Required	Yes/No	YES
2.7.1	Armour Type and material		GI ROUND
2.7	Outer sheath Required	Yes/No	YES
2.7.1	Outer Sheath material and type (ST 1 or ST 2)		ST2
2.8	Cable Drum Type (Wooden/Steel)		Wooden
2.8.1	Drum length required	m	As per site requirement. No jointing kit is allowed.
2.8.2	Cable quantity tolerance		+5%

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
3.0	SPECIFIC REQUIREMENT		
3.1	Outer Sheath type (Fire Survival (FS) /Flame Retardant Low Smoke (FRLS)/ FRLSZH		FRLS
3.2	Fire Protective paint required	Yes/No	No
3.3	Instrumentation Cable type(Pair/Triad/Quad/ Quintuple)		

D. DATA SHEET FOR DISTRIBUTION TRANSFORMER

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1)	No. of transformers	Nos	As per BOQ
2)	Service		Indoor Installation.
3)	Type		Core type
4)	Overall dimensions of transformer		To be indicated by the Manufacturer. But confirm accommodation in the space shown in drawing with clearance of 1000mm (Minimum) on all sides
5)	Weight		To be indicated by the Manufacturer.
6)	Rating		
	a. Rated capacity	KVA	2500
	b. Rating enhancement with forced air fans		Not Applicable
	c. Rated primary voltage	Volts	33000 V
	d. Rated secondary voltage		433 V
	e. Rated frequency	Hz	50
	f. No. Of Phases		3
	g. Cooling		Cast resin Dry type, Air Natural (AN) + 2 Fans
	h. Temperature rise by resistance of winding	Deg C	90 Deg C - As per IS 11171
	i. Ambient temperature	Deg C	50°C Peak
			45° C Daily average
			18° C Minimum
	j. Overload capacity		As Per IEC 60076-12
	k. Class of Insulation		CLASS - F
7)	Enclosure (OEM Approved)		"Enclosed Dry-Type" as per IS:2026-11
			IP - 23 (Louvers with perforated sheet)
8)	Winding and Vector Group		Copper winding
			Dyn11 connection,
9)	Tap changer		a) Onload tap changer with RTCC
	High Voltage		- 10% to + 10% at steps of 2.5%
10)	Impedance at rated current frequency and at 75°C	%	6.25 % (approx.)
			Inline to Tolerances in IS
11)	Transformer losses		As per ECBC-2017
11.1)	Load Losses at 50 % of Load	KW	To be indicated by the Bidder
11.2)	Load Losses at 100 % of Load	KW	To be indicated by the Bidder
13)	Efficiency at 0.8 Pf		
	a. at 50% load		To be indicated by the Bidder
	b. at 75% load		
	c. at full load		
14)	Efficiency at Unity Pf		
	a. at 50% load		To be indicated by the Bidder
	b. at 75% load		
	c. at full load		
14)	Neutral		Effectively Earthed - Neutral to be separately brought out
15)	Terminals		
	a) Primary side		HV Cable Box – 26.3 kA
			Suitable for termination of
			1 R # 3C 400sqmm XLPE ALUMINIUM ARMOURED
	b) Secondary side		LV Cable Box - 55kA
			Flange Suitable for termination of

			3PH 4W 4000 A CU SANDWICH BUS DUCT
16)	Insulation level		
	BIL - HV		170 Kvp / 70 kV rms
	BIL - LV		3 kV rms
17)	Fittings & Accessories		Following fittings and accessories shall be provided. IEC 60076-11 & 60076-12
			Lifting eyes or lifting lugs.
			Bi – directional wheels
			HV and LV terminals
			Earthing terminals
			Pulling holes on the under base
			Winding temperature control system:
			Fan Control Circuit
			Neutral CT: As per SLD/BOQ (specification to be matched with LT Panel Side CT ratings)
18)	Transformer shall have a rating plate of weatherproof stainless-steel material placed in a clear position. Nameplate information as called for by standards shall be provided. This includes:		
			- Type of transformer
			- Manufacturer's name
			- Serial number
			- Year of Manufacture
			- Insulation Level
			- Number of phases
			- Rated power
			- Rated frequency
			- Rated voltage
			- Rated currents
			- Vector Group
			- Impedance voltage at rated current
			- Type of Cooling
			- Total Mass
			- Temperature rise of windings
19)	Noise Level		As per NEMA TR 1
20)	Paint Shade		Epoxy Shade - RAL 7032
	Note:		
	Information by supplier as indicated above shall be furnished by the tenderer along with the tender, otherwise the tender is not liable to be considered.		

E. DATA SHEET FOR HT CABLES

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1.0	SYSTEM DATA		
1.1	System Voltage with voltage variation	V	33KV
1.2	Short circuit for 1 Sec.	KA (rms)	26.3
1.3	Design ambient temperature of cable	deg. C	45
1.4	Laying (underground/air/duct/trench)		Duct/ Trench/Cable tray
2.0	<u>CABLE DATA</u>		
2.1	Type of Cable(HV Power/LV Power/Control/Instrumentation/Telecommunication)		HV Power
2.2	Rated voltage of cable (U ₀ /U)	kV	36kV
2.3	Core (Multi/single)		Multi core
2.4	Conductor (Aluminium/Copper)		Aluminum
2.4.1	Conductor (stranded/solid)		Refer BOQ
2.4.2	Conductor Screen required	Yes/No	Yes
2.4.3	Effective cross sectional area of conductor	sq.mm.	Refer BOQ
2.5	Insulation material (XLPE/PVC/PTFE/etc.)		XLPE
2.5.1	If PVC, type of insulation (Type A or C)		
2.5.2	Insulation screen required	Yes/No	
2.6	Inner Sheath required	Yes/No	YES
2.6.1	Inner sheath material and type (A or C)		ST2
2.7	Armour Required	Yes/No	YES
2.7.1	Armour Type and material		STRIP
2.7	Outer sheath Required	Yes/No	YES
2.7.1	Outer Sheath material and type (ST 1 or ST 2)		ST2
2.8	Cable Drum Type (Wooden/Steel)		WOODEN
2.8.1	Drum length required	m	AS PER REQUIREMENT.

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
			NO JOINTING KIT IS ALLOWED
2.8.2	Cable quantity tolerance		+5%
3.0	SPECIFIC REQUIREMENT		
3.1	Outer Sheath type (Fire Survival (FS) /Flame Retardant Low Smoke (FRLS)/ FRLSZH		FRLS
3.2	Fire Protective paint required	Yes/No	NO

F. DATA SHEET FOR BUSBAR TRUNKING/BUSDUCTS

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1.0	General		
1.1	Bus Bar arrangement		Refer BOQ
1.2	Bus Bar configuration		Refer BOQ
1.3	Phase, Wire (3W/4W)		Refer BOQ
1.4	Rated operational voltage	V	415
1.5	Rated insulation voltage	V	1100
1.6	Rated Dielectric voltage	kV in r.m.s	75
1.7	Rated impulse withstand voltage	kV	28
1.8	Rated frequency	Hz	50
1.9	Degree of protection		IP 42 for indoor IP 66 for outdoor
2.0	Bus Bar		
2.1	Bus Bar Ratings	A	Refer BOQ
2.2	Short circuit rating	kA	Refer BOQ
2.3	Bus Bar material (Phase / Neutral)		Refer BOQ
2.4	Bus Bar material (earth bus bar)		Refer BOQ
2.5	Bus Bar insulation		CLASS F
2.6	Fire rating		Refer BOQ
2.7	Joint type		Refer BOQ
3.0	Bus enclosure		
3.1	Enclosure material		As per OEM standard
3.2	Paint		RAL 7035
4.0	End Feed unit/Centre feed Unit		
4.1	End Feed unit Required	Yes/No	Yes
4.2	End Feed unit rating	A	Refer BOQ
4.3	Centre feed Unit Required	Yes/No	NO
4.4	Centre feed Unit rating	A	
5.0	Tap off Units		
5.1	Tap off unit Required	Yes/No	Yes
5.2	Tap off unit Qty. and rating	A	Refer SLD
5.3	Tap off unit type		Refer BOQ
6.0	Terminations		
6.1	Flanged End Terminations required	Yes/No	Yes

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
6.2	Cu Flexible Connections required	Yes/No	Yes

BUSDUCTS			
SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1.0	<u>DESIGN PARTICULARS</u>		
1.1	Type of Bus Duct		SANDWICH TYPE
	Applicable standard		Latest IS/IEC standards
	System		3 phase 4 wire
	Class of Insulation		Class F
1.2	Type of Cooling		Self cooled
1.3	Installation Indoor/Outdoor		Indoor
1.4	Nominal Service Voltage	kV	0.415
1.5	Frequency	Hz	50
1.6	Continuous Current Rating of Bus Ducts under Site Conditions	A	Refer SLD
1.7	Basic Impulse Insulation Level (1.2 x 50 micro second wave)	kV (Peak)	75
1.8	One minute Power Frequency Withstand Voltage	kV (Peak)	28
1.9	Momentary Current Rating	kA (Peak)	105
1.10	Short Time Current Rating for one second	kA (RMS)	50kA
1.11	Design maximum Temperature (Hot Spot) of Busbars at Rated Current (a) Plain joint (b) Silver plated joints	°C	45 ° C 60 ° C
1.12	Design maximum Temperature (Hot Spot) of Enclosure at Rated Current	°C	Not to exceed 70 ° C
1.13	Busbar Material		As per SLD
1.14	Busbar Section	sq.mm.	Rectangular section

BUSDUCTS			
SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1.15	Bus Enclosure Material & thickness	mm	Bidder to decide
1.16	Shape of Enclosure		Bidder to decide
1.17	Material of Phase Barriers & thickness		
1.18	Phase Clearance (Minimum) - Phase to Phase - Phase to Earth	mm	25 19.4
1.19	Type of Joints between Adjacent Sections of Bus Conductor Welded/Bolted		Bolted
2.0	<u>INSULATORS AND SEAL OFF BUSHING</u>		
2.1	Rated Voltage	kV	0.433
2.2	<u>ONE MINUTE POWER FREQUENCY WITHSTAND VOLTAGE</u>		
2.2.1	Dry	kV (rms)	2.5kV rms
2.2.2	Wet	kV (rms)	
2.3	Impulse Withstand Voltage (1.2 x 50 micro-second Wave)	kV	75
2.4	Minimum Creepage Distance	mm	25 mm/kV
2.5	Material of Insulators		
2.6	Current rating of Seal of Bushings	A	Refer SLD
2.7	Material of Seal Off Bushings		Porcelain
3.0	<u>LINKS</u>		
3.1	<u>DISCONNECTING LINKS</u>		
3.1.1	Quantity		

BUSDUCTS			
SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
3.1.2	Rated Current	A	Refer SLD
3.2	<u>SHORTING LINKS</u>		
3.2.1	Location		Bidder to indicate
4.0	<u>BUS DUCTS TENTATIVE LENGTH</u>		
4.1	Bus Duct length.	M	Refer BOQ/Drawings
4.2	90° Bend		Refer BOQ/Drawings
4.3	Tees		Refer BOQ/Drawings
4.4	No. of Terminations		Refer BOQ/Drawings
5.0	<u>GENERAL</u>		
5.1	<u>EARTHING CONDUCTOR</u>		
5.1.1	Material Size		2Runs of 50 x 10 sq.mm GI Earth flat conductor
5.2	<u>FINISH OF BUS ENCLOSURE</u>		
5.2.1	Exterior		RAL 7032
5.2.2	Interior		Glossy white
5.3	Layout Drawing Reference No.		
5.4	Rain hood required	Yes/No	Yes for outdoor
6.0	<u>TESTS</u>		
6.1	Routine test		As per QAP

BUSDUCTS			
SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
6.2	Acceptance tests		Bidder to Produce the test reports
6.3	Type tests		Bidder to Produce the test reports
6.4	Tests on components such as insulators, seal-off bushings, bolted and flexible joints, busbars, enclosure material, galvanizing of supporting structures, CTs, VTs and fuses		Bidder to Produce the test reports
7.0	<u>START-UP AND ESSENTIAL SPARES</u>		Bidder to recommend

G. DATA SHEET FOR HT PANELS

Sl. No.	DESCRIPTION	UNITS	Technical Data
A	SYSTEM PARAMETERS		
1	Nominal System voltage	kV	33
2	Highest System voltage	kV	36
3	Phases		3
4	Frequency	Hz	50
5	System neutral earthing		As per vector group of transformer
6	Short time withstand current rating for 3 Sec	kA	26.3
7	Rated peak withstand current	kA Peak	78.75
8	Rated Short Circuit PF withstand Voltage	kV RMS	70
9	Rated Lightning impulse withstand Voltage	kV peak	170
10	IAC AFLR Rating (CB compartment, Bus Bar compartment & Cable Compartment) for 1 Sec	kA	26.3
11	Design Ambient Temperature	Deg C	45 Deg C
12	Maximum Relative Humidity	%	0.95
B	GENERAL DATA for 33 kV SWITCHGEAR		
1	Type of Breaker		Vacuum Circuit Breaker
2	Type of Insulation		Air Insulated
3	Degree of Protection		IP4X/IP5X
4	Mechanical indication for CB		Yes
5	Cable entry		Bottom with rear access
C	PANEL ENCLOSURE		
1	Type of Arrangement		Free Standing
2	Powder Coating thickness		100 microns (+/-25 micron)
3	Indoor/Outdoor		Indoor for HT panel-2/ Outdoor for RMG & HT panel-1
4	Material of enclosure		CRCA
5	Enclosure Ingress Protection Class		IP42 for Indoor/IP55 for Out Door
D	BUS BAR INFORMATION		
1	Material		Copper
2	Material Purity		0.999
3	Busbar Insulation		PVC Sleeve
4	Main Bus Bar Rating	A	800

5	Rated Continuous Current @ Design Ambient temp. 40 Deg Cel	A	800
E	POWER CABLE COMPARTMENT		
1	Power Cable entry		Bottom with rear access for RMG & HT panel-1 AND Top rear Access for HT panel-2
F	CIRCUIT BREAKER		
1	Type of Breaker		Vacuum Circuit Breaker
2	Rated Nominal Voltage	kV	33
3	Maximum Voltage	kV	36
4	Rated Short-Circuit withstand current	kA	26.3
5	Short circuit-Current Withstand Time	Sec	3 Sec
6	CB rated Current		
a)	Incomer	A	800
b)	Outgoing feeder Breaker	A	800
c)	Bus Sectionalizer & Bus-coupler Breaker	A	800 & NA
7	Power Frequency Withstand Voltage	kV rms	70
8	Lightning Impulse Withstand Voltage	kV peak	170
9	First pole to clear factor		1.5
10	Closing Time	ms	<60 ms
11	Opening Time	ms	<30 ms
12	Arcing Time	ms	<15 ms
13	Spring Charged after CO		Yes
14	Rated Operating duty cycle		O – 0.3 Sec – CO – 3 min – CO
15	Trip Coil Operating Voltage	V DC	110
16	Trip Coil Operating Voltage Range	%	70% - 110%
17	Closing Coil Operating Voltage	V DC	110
18	Closing Coil Operating Voltage Range	%	85% - 110%
19	Spring Charging Motor Voltage	V AC	230 V
20	Spring Charging Motor Voltage range	%	85% - 110%
21	Endurance Class Classification		M2/E2/C2
22	Auxiliary contacts		6NO+6NC for Employers future use besides scheme requirement

23	Operating Mechanism		Motor wound spring charged stored energy type
H	CONTROL WIRING		
1	Type:		PVC
2	Insulation Grade	V	1100
3	Auxiliary Bus wire Size (minimum)	mm	Min 2.5 Sq mm
4	Control circuit (Ac/DC) wire size (minimum)	mm	Min 1.5 Sq mm
5	CT Circuit wire size (minimum)	mm	Min 2.5 Sq mm
6	PT Circuit wire size (minimum)	mm	Min 2.5 Sq mm
J	PAINTING / FINISHING		
1	Color		RAL 7035
2	Paint thickness		100 microns (+/-25 micron)
K	CURRENT TRANSFORMERS		(As per SLD FOR HT panel 1&2 AND CT Specifications for RMG as per TANGEDCO Norms)
1	Rated primary voltage		33 kV
2	Type of CT		1-Phase
3	Max temp rise		As per IEC:61869-2
4	Class of Insulation		Class B
5	One minute power frequency withstand voltage between secondary terminal & earth		2kV
6	Accuracy class		Metering: 0.5 Protection: 5P20 for HT panel 1& 2
L	VOLTAGE TRANSFORMER		(As per SLD FOR HT panel 1&2 AND VT Specifications for RMG as per TANGEDCO Norms)
1	Rated primary Voltage		33kV
2	IEC Standard		IEC:61869-3
3	Type		1-phase
4	Voltage ratio (kV)		$(33/\sqrt{3})/(0.11/\sqrt{3})$
5	Rated Voltage Factor		1.2 continuous and 1.9 for 30 seconds
6	Nos. of Secondary cores		2
7	Accuracy of Secondary core		Metering Protection 0.5 3P for HT panel1&2
8	Class of insulation		Class B
9	Rated output burden (Minimum)		50VA
M	ACCESSORIES For RMG and HT panels		
	T-N-C Switch (Trip-Neutral-Close)		Provide
	Local remote switch		Provide

	INDICATION LAMPS		COLOUR OF LAMPS A) ON- RED B) OFF- GREEN C) AUTO TRIP- AMBER D) SERVICE POSITION -BLUE E) TEST POSITION -WHITE F) SPRING CHARGED -BLUE G) TRIP CIRCUIT HEALTHY -WHITE H) CONTROL SUPPLY HEALTHY -WHITE I) READY TO CLOSE -YELLOW
	Alarm Scheme		Hooter along with 16W annunciator
	Space heater with ON/OFF Switch		Provide
	Power Pack		Provide
	Demand controller		Provide
	Load Manager / Multi-function meter		As per SLD of All HT panels
	Auxiliary Relay		Provide as required
N	PROTECTION RELAYS		<u>For Incoming Feeders of all RMG& HT panels:</u> Microprocessor based 3 O/C and 1 E/F with selectable IDMTL / DMTL 51&51N, 86, 95, 80,27, 59, 81 and Phase reverse relay (PRR)/Phase failure relay (PFR)
			<u>For Outgoing Feeders of RMG& HT panel 1:</u> 3O/C & 1 E/F IDMTL relay, 95, 86, 94,51&51N and 50 LBB
			<u>For Outgoing Feeders of HT panel 2:</u> 3O/C & 1 E/F IDMTL relay, 51, 51N, 50, 50N, 67, 67N, 51NS, 64R,25, 27, 74TC & 86 95,50LBB
O	CABLE TERMINATION		<u>For All HT Panels:</u> Suitable for 1R - 33 KV 3C 400 Sq.mm XLPE Aluminium Armoured Conductor for Incoming and 1R - 33 KV 3C 400 Sq.mm XLPE Aluminium Armoured Conductor for Outgoing. The panel shall be provided with suitable removable busbar plate for future extension.

H. DATA SHEET FOR LT PANELS

SL. NO.	ITEM	UNIT	
1.0	<u>SWITCHGEAR & BUSBAR RATING</u>		
1.1	RATED VOLTAGE, PHASES & FREQUENCY		415V & 3 PH & 50 Hz
1.2	SYSTEM NEUTRAL EARTHING: EFFECTIVELY/NON-EFFECTIVELY		EFFECTIVELY Earthed
1.3	MAXIMUM SYSTEM VOLTAGE		457V
1.4	ONE MINUTE POWER FREQUENCY VOLTAGE		
	A) POWER CIRCUITS B) CONTROL CIRCUITS C) AUX. CIRCUITS CONNECTED TO SEC. OF CTS	VOLTS VOLTS VOLTS	2500 1500 2000
1.5	CONTINUOUS CURRENT RATING OF BUSBARS UNDER SITE REFERENCE AMBIENT TEMPERATURE		REFER SLD
1.6	REFERENCE AMBIENT TEMPERATURE	°C	45
1.7	MAXIMUM TEMPERATURE OF BUSBARS, DROPPERS AND CONTACTS AT CONTINUOUS CURRENT RATING UNDER SITE REFERENCE AMBIENT TEMPERATURE	°C	85°C FOR NON-SILVER-PLATING JOINTS 105°C FOR SILVER PLATING JOINTS
1.8	SHORT CIRCUIT WITHSTAND FOR BUSBARS AND DROPPERS A) SHORT TIME (1 SEC.) AT 415V B) DYNAMIC RATING	kA (RMS) kA (PEAK)	As per SLD kA (rms) 105kA (peak)
1.9	PHASE CROSSOVER ARRANGEMENT REQUIRED		YES/NO
2.0	<u>SWITCHGEAR PARTICULARS</u>		REFER SLD
3.0	<u>SWITCHGEAR CONSTRUCTIONAL REQUIREMENTS</u>		
3.1	THICKNESS OF SHEET STEEL COLD ROLLED	mm	Frame Doors/ Covers Partitions 2 2.5 1.6
3.2	DEGREE OF ENCLOSURE PROTECTION - IP52/IP42/IP54/IP55		AS PER IS:13947 For Indoor Panels IP 4X For indoor panels

SL. NO.	ITEM	UNIT	
			IP 55
3.3	DEGREE OF ENCLOSURE PROTECTION AGAINST EXTERNAL MECHANICAL IMPACTS		AS PER IEC – 62262 IK08
3.4	PANEL TYPE- FRONT OPERATED FRONT MAINTAINED/FRONT OPERATED BACK MAINTAINED		RAL 7035
3.5	EARTHING BUS MATERIAL SIZE	mm	Cu As per OEM
3.6	PURCHASER'S EARTHING CONDUCTOR MATERIAL SIZE	mm	GI As per OEM
3.7	CLEARANCES IN AIR OF LIVE PARTS		As per type tested design complying to required BIL level
3.8	METAL ENCLOSED BUSDUCT/BUS TRUNKING ENTRY TO CUBICLES IF REQUIRED		As per layout
3.9	FORM OF SEPARATION AS PER IEC 61439-1		Form 4b
3.10	REQUIREMENT OF ARC RESISTANCE FEATURE		YES
3.11	SALT SPRAY TESTING FOR 500 HRS		YES/NO
3.12	TYPE OF PAINTING/COATING		EPOXY/ POLYURETHANE/SYNTHETIC ENAMEL/POLYESTER/RUBBER
3.13	COLOUR FINISH SHADE INTERIOR EXTERIOR		RAL 7035
4.0	<u>STARTERS</u>		
4.1	TYPE		(a) Refer SLD
4.2	CONTACTOR RATED DUTY		AS PER IS:60947
4.3	UTILISATION CATEGORY		(a) DOL - (b) REV - (c) Y-Δ - (d) ANY OTHER
4.4	FOR Y-Δ STARTER OPEN/CLOSED TRANSITION		
4.5	CONTROL TRANSFORMER:		Not required

SL. NO.	ITEM	UNIT	
4.5.1	SEPARATE FOR EACH MODULE		YES/NO
4.5.2	COMMON FOR EACH SWITCHGEAR SECTION WITH 100% STANDBY		YES/NO
4.6	SINGLE PHASING PREVENTOR REQUIRED		YES
4.7	RELAY (i) THERMAL OVER LOAD RELAY RESET (ii) ELECTRONIC OVERLOAD RELAY		HAND HAND
4.8	MOTOR PROTECTION CIRCUIT BREAKER TO BE CONSIDERED		YES
4.9	LOW BURDEN TYPE CONTACTORS (SUITABLE FOR DIRECT OPERATION FROM DCS/PLC)		YES
5.0	CIRCUIT BREAKER		
5.1	CIRCUIT BREAKER TYPE		REFER SLD
5.2	VOLTAGE, FREQUENCY & NO. OF PHASES		415V, 50Hz & 3Ph
5.3	RATED BREAKING DUTY		B-0.3 SEC-MB-3 SEC-MB
5.4	ARRANGEMENT IN PANEL		AS PER IEC 61439&60439
5.5	SHORT CIRCUIT WITHSTAND CURRENT FOR 1 SEC. DURATION	kA	REFER SLD
5.6	RATED MAKING CURRENT	kA (PEAK)	105 kA (peak)
5.7	RATED CURRENT AT SITE REFERENCE AMBIENT TEMPERATURE	A	AS PER REQUIREMENT
5.8	TYPE OF OPERATING MECHANISM		MOTOR WOUND SPRING CHARGED
5.9	KEY INTERLOCKING REQUIRED		AS PER SLD
5.10	SHUNT TRIP REQUIRED		YES

SL. NO.	ITEM	UNIT	
5.11	PROTECTION REQUIRED (A) RELAYS/ RELEASES MICROPROCESSOR BASED (B) RELAY/RELEASE TYPE & SETTINGS (C) UNDER VOLTAGE RELEASE REQUIRED SETTING (D)SHUNT TRIP REQUIRED		AS PER SLD YES
5.12	BREAKER SCADA COMPATIBILITY REQUIRED		NO
5.13	CONTROL VOLTAGE (a) FOR SPRING CHARGING MOTOR (b) FOR CLOSING/TRIPPING	V AC/DC	240V AC
5.14	EMERGENCY MANUAL OPERATION REQUIRED IN ADDITION TO ELECTRICAL OPERATING DEVICES (a) FOR SPRING CHARGING & CLOSING (b) FOR TRIPPING		YES YES
5.15	ANNUNCIATOR REQUIRED		YES
5.16	BREAKER CONTROL SWITCH- PISTOL GRIP TYPE/ POLE DISCREPANCY TYPE		
6.0	MCCB's		
6.1	MOULDED CASE CIRCUIT BREAKERS TO BE PROVIDED. (a) FOR MOTOR CONTROL CIRCUITS (b) FOR OTHER CIRCUITS		YES YES
6.2	VOLTAGE, FREQUENCY & NO OF PHASES		
6.3	TYPE OF RELEASE		REFER SLD
6.4	RATED OPERATING DUTY		
6.5	RATED BREAKING CAPACITY (AT 415V 0.25 P.F.)	kA(RMS)	REFER SLD
6.6	RATED MAKING CURRENT	kA (Peak)	105 (Peak)

SL. NO.	ITEM	UNIT	
6.7	RATED CURRENT AT SITE REFERENCE AMBIENT TEMPERATURE		AS PER REQUIREMENT
6.8	ON/OFF OPERATION MANUAL REMOTE POWER OPERATED		YES NO
6.9	RELEASES REQUIRED OVER LOAD SHORT CIRCUIT EARTH FAULT UNDER VOLTAGE		REFER SLD
6.10	NUMBER OF AUXILIARY CONTACTS EXCLUSIVELY FOR PURCHASERS USE		AS PER REQUIREMENT
6.11	EARTH FAULT PROTECTION FOR TPN MCCB- THROUGH IN BUILT RELEASE WITH A SEPARATE NEUTRAL CT INPUT OR THROUGH CBCT, ELR AND SHUNT TRIP COIL		REFER SLD
7.0	<u>CURRENT TRANSFORMERS</u>		
7.1	TYPE		CAST RESIN
8.0	POTENTIAL TRANSFORMERS		
8.1	TYPE		CAST RESIN
8.2	FUSES OR MPCB/MCB PROVIDED ON PRIMARY AND SECONDARY SIDE		PRIMARY - MPCB SECONDARY - MCB
9.0	INDICATION METERS		
	ANALOGUE/DIGITAL		REFER SLD
	ACCURACY CLASS		REFER SLD
	IF ANALOGUE SIZE 144MM X 144 MM OR 96MM X 96MM		REFER SLD
	TAUT BAND		YES
	COMMUNICATION PROTOCOLS		MODBUS/ETHERNET TCP IP/ 61850/PROFIBUS
10.0	RELAYS		NUMERICAL

SL. NO.	ITEM	UNIT	
	COMMUNICATION PROTOCOLS FOR RELAYS		IEC 61850/IEC 101/IEC 103/DNP 3
	CONTROL SUPPLY FOR SPACE HEATER, SPRING CHARGING MOTOR, SOCKET, PANEL ILLUMINATION LAMP PROTECTED BY		MCB
11.0	CABLE GLANDS IN VENDORS SCOPE		YES

I. DATA SHEET FOR APFCR PANELS

SL. NO.	ITEM	UNIT	
1.0	Application		Capacitor Controlled Passive and Active Harmonic filter for Power factor correction
2.0	Quantity		Refer SLD
3.0	Rated Voltage	V	480/525
4.0	Frequency	Hz	50
5.0	Ambient temperature	°C	45
6.0	Target P.F setting		0.99
7.0	No. of relay output terminals	Nos.	Refer SLD
8.0	Rated Capacity at UPF		Refer SLD
9.0	Auto / Manual operation		Auto/Manual
10.0	Display Parameters		Voltage, Current, P.F
11.0	Safety lock out time	Sec	OEM standards
12.0	Switching Principle		OEM standards
13.0	Switching delay		OEM standards
	(a) On delay	Sec	OEM standards
	(b) OFF delay	Sec	OEM standards
14.0	Communication port		OEM standards

AHF DATA SHEET		
Sl.no	Description	Technical Particulars
1	AHF RATING	As Per SLD
2	System Voltage (RMS)	350 - 525 V
3	Fundamental Frequency (Hz)	50 ± 5%
4	System configuration	3P4W
5	Power Semiconductor Devices	IGBTs
6	Peak Compensating Current	2.2 Times RMS value
7	Harmonic Compensation Range	Odd harmonics up to 51st order
8	Selective Harmonic Compensation	From 0% to 100% for all 51 Harmonics
9	Reactive Power Compensation	Any power factor (inductive to capacitive). Full dynamic control.
10	Harmonic Attenuation Factor	More than 97% at rated load
11	Load Current Balancing	Yes
12	Cooling	Forced air cooling
13	Cable entry	TOP/ Bottom
14	Mounting	Floor Mounting

15	Ingress Protection Level	IP20
16	Controller Type	Digital Controller
17	Control Method	OEM standards
18	Dynamic Response Time	100 Micro-seconds
19	HMI Display Type	7-inch Capacitive Touchscreen Display
20	Remote Monitoring	MODBUS / software on USB Port
21	Operating Temperature Range	0°C to 50°C
22	Active Power Loss	Less than 3%
23	Parallel Operation	Yes
24	Short - Circuit protection	Yes
25	Color	OEM standards
26	Noise Level	<65 db

J. DATA SHEET FOR VFD

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1.0	Application		Pumps/compressors/fans/blowers/AHU/
2.0	Quantity		As per BOQ
3.0	(a) Starting/rated torque		As per HVAC requirement
	(b) Type of converters		Voltage source IGBT based Inverter with PWM technology
	(c) Inverter capacity at specified pf		As per HVAC requirement
	(d) Rated Current		As per HVAC requirement
	(e) Load power factor		As per HVAC requirement
	(f) Max. continuous current		As per HVAC requirement
	(g) Rated voltage with number of phases		As per HVAC requirement
	(h) Rated frequency		50Hz
	(i) Converter Bridge		6/12/18/24 pulse
	(j) Quadrant operation		1
	(k) Duty class (cl.no.3.4)		II
4.0	Power supply voltage		415 V, 3ph, 50 Hz
5.0	Voltage variation		±10%
6.0	Frequency variation		±5%
7.0	Combined voltage and frequency variation		±10%
8.0	Power system fault current/ time	kA/sec	Refer SLD
9.0	Location		Indoor
10.0	Whether in air conditioned room	Yes/no	No
11.0	Average ambient temperature	°C	Refer Project data
12.0	Design ambient temperature	°C	45
13.0	Relative humidity	%	Refer Project data
14.0	Motor rated kW/ RPM/ voltage		Refer SLD
15.0	Motor data sheet (driven equipment data)		Refer motor data sheet no.....
16.0	Drive efficiency		98% or more
17.0	Drive power factor		>96%
18.0	Speed control range	RPM/ %	As per HVAC requirement
19.0	Type of braking		Dynamic/ regenerative braking
20.0	Speed accuracy		
21.0	Closed loop/ open loop		

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
22.0	Type of tachogenerator		Digital (pulse type)
23.0	Remote operation		DCS/ PLC
24.0	Miscellaneous		
24.1	Soft-start	Yes/no	
24.2	Flying restart	Yes/no	
24.3	Auto restart	Yes/no	
25.0	Cable details		
25.1	Incoming cable size and type		Refer Cable schedule
25.2	Outgoing cable size and type		Refer Cable schedule
26.0	Cable entry	Top/bottom	Refer drawings

K. DATA SHEET FOR UPS

SL. NO.	ITEM	UNIT	TECHNICAL PARTICULARS
1	Nominal Input Voltage	V	415v
2	Input Frequency (Hz):	Hz	50 Hz
3	Topology		True online double conversion, IGBT Rectifier & 3 Topology inverter, Transformer less, Modular Scalable UPS System
4	UPS frame Capacity		Vendor to Refer SLD/ BOQ.
5	Scalability (parallel frames)		Vendor to Confirm.
6	Power Modules per frame		Vendor to confirm.
7	Dual Input Feed (Mains & Aux mains)		Necessary
8	Type of power supply (input/output)	Phase	3 Phase + N (Both Input / Output)
9	Input voltage and tolerance	V	380V/ 400V/415V (line to line) with tolerance
10	Power factor		@ 100 & Load , P F = 0.99
11	Input DistortionTHDI		Sine-wave THDi = < 3 % @ 100% load
12	Output Rated Voltage(V)	V	3 x380/220 V+ N, 3 x400/230 V + N, 3x 415/240V+ N
13	Output Frequency(Hz)	Hz	50 Hz.
14	Crest - Factor		3:1
15	Overload Capability on Inverter		125 % load 10 min. 150 % load 60 sec.
16	UPS Efficiency	%	The typical overall efficiency (AC/AC, on-line mode) shall be> 95.5 % @ 100% load 95.5% @ 75% load 95% @ 50% load
17	Performance EN 62040-3 (VFI-SS-111) EMC classification, Emission Immunity class Certification - CE, IEC Manufacturing		Vendor to confirm.
18	Electromagnetic compatibility		Vendor to confirm.
19	UPS operation ambient temperature range		0°C to 40°C
20	Bypass static switch each module		Required.

21	Maintenance Bypass		Required
22	Warranty		As per Clients requirements

L. DATA SHEET FOR DG SETS

Sr. No	ITEM	UNIT	
1.0	GENERAL		
1.1	Designation		Emergency DG System
1.2	Applicable Standard		Centre/State Pollution Control Board norms, ISO 3046,8528-1 / BS 649,5514., IS
2.0	SCOPE		
2.1	DG Foundations		By Others
2.2	DG Set as per BOQ		By DG System Vendor
2.2	Acoustic Enclosure		By DG System Vendor
2.3	Insulated Engine exhaust Piping with fittings, specials, valves and supports etc complete		By DG System Vendor
2.4	Chimney as per CPCB with supports		By DG System Vendor
2.5	Diesel day Tanks with tank mounted instruments for DG at inside acoustic canopy		By DG System Vendor
2.6	Fuel piping from HSD to Main tank and Day tank to DG		By DG System Vendor
2.7	415 V DG switchgear isolation Panel and DG sync panel		By DG System Vendor
2.8	Suitable Bus duct (NSPBD)connection between Isolation panel to DG terminal		By DG System Vendor
2.9	Busduct / Cable connection between Isolation panel to PCC		By DG System Vendor/To Be decided by Bidder
2.10	AMF starting		By DG System Vendor
2.11	Control and Instrument cabling between DG set, DG control, DG switchgear and instruments and between any to equipment supplied by this Vendor		By DG System Vendor
2.12	DG set Foundation drawings		By DG System Vendor
2.13	Services		
	a) General design, materials, construction features, manufacture, shop inspection and testing at the manufacturer's works, delivery at site, handling at site, erection, testing, commissioning, performance testing and handing over of Diesel Generator set with Acoustic Enclosures, inbuilt isolation module with necessary items.		By DG System Vendor
	b) DG control Panel		By DG System Vendor
	c) Obtaining Statutory Approvals		
	i. Central Pollution Control Board		By DG System Vendor
	ii. Electrical Inspector		By DG System Vendor
	iii. Local Electrical Utility		By DG System Vendor
	iv. Chief Controller of Explosives if any		By DG System Vendor

Sr. No	ITEM	UNIT	
	v. Any other deemed necessary to install and commission & operation of DG		By DG System Vendor
3.0	DIESEL GENERATING SET		
3.1	<u>GENERAL</u>		
3.1.1	Designation		Emergency DG Set
3.1.2	Numbers Required	Sets	As per BOQ
3.1.3	Rated kVA	kVA	2250 (prime rated)
3.1.4	Location		Inside DG room (DG With Acoustic Enclosure)
3.1.6	Fuel		HSD as per IS: 1460
3.2	<u>DESIGN DATA</u>		
3.2.1	Continuous output at site conditions		Min 80% of Rated kVA
3.2.2	Overload capability for one (1) hour in twelve (12) consecutive hours of operation		10%
3.2.3	Output		
	a) Output Voltage		415 V, 3 phase, 50 Hz AC
	b) Power Factor		0.8 pf
3.2.4	Permissible Variation		
	a) Voltage		+ 10 %
	b) Frequency		+ 5 %
3.2.5	Noise Level		75 dbA at 1 M from acoustic enclosure in all directions
3.2.6	Largest Motor to be started with Voltage dip limited to 15%		
	a) Motor Rating	kW	308 kW (tentative) and will be confirmed during design stage
	b) Method of starting		Star Delta
3.2.7	Harmonic Loading		As per the IEEE limitation.
3.3	<u>OPERATION REQUIREMENTS</u>		
3.3.1	Black Start Capability		Required
3.3.2	Starting		Electrical start from Remote/ Local & Manual with AMF starting
3.3.3	Stopping		Electrical stop from Remote/ Local & Manual
3.3.4	Parallel Operation		
	a) If more than one dg is in operation, whether in isolation / in parallel		Suitable for parallel operation whenever required
	b) DG Sets in parallel with Grid		No
	c) Momentary parallel operation with Grid		No
	d) Under frequency Load shedding scheme		No
3.3.5	Period for taking Load from 'Start' impulse	sec	<15 sec
3.4	<u>DIESEL ENGINE</u>		
3.4.1	General		
	a) Numbers Required	Sets	As Per BOQ
	b) Applicable Standard		ISO 3046,8528-1 / BS 649,5514.
	c) Rating		To suit DG Design Data
3.4.2	Engine Cooling System		Radiator Cooled
3.4.3	Cooling Tower		
	a) Type		Not Applicable

Sr. No	ITEM	UNIT	
	b) Capacity	TR	Not Applicable
3.4.4	Cooling Water Pumps		
	a) Type		Not Applicable
	b) Capacity (Flow)/ Head	m3/hr	Not Applicable
3.4.3	Engine Starting System		Electric Starting
	a) Battery		
	Battery Type		Maintenance free
	Capacity	AH	minimum three (3) continuous Cold starts
	b) Battery Charger		From AC Mains & Engine driven Battery charger
3.4.4	Fuel Oil Day Tank		
	a) Type		Rectangular MS Fabricated
	b) Applicable Standard		Generally as per IS 10987
	c) Capacity		990 Ltrs day tank
	d) Location		As per DG room layout
3.4.5	Instruments on each day tank		
	Level Indicator & level switches		Yes
	Type		Bidder to specify
	Range		To suit day tank
3.4.6	Air Intake and Exhaust system		
	Intake Air Filters		Required
	Exhaust Silencer		Heavy duty Residential Type
	Height of stack		As per CPCB/KPCB requirements
	EXHAUST PIPE/ STACK		Exhaust pipe shall be considered with necessary MS supports arrangements
3.5	ALTERNATOR		
3.5.1	General		
	a) Numbers Required	Sets	As per BOQ
	b) Applicable Standard		IS 4722/ BS 5000 Part 99
	c) Rating		Suitable for 2250kVA Prime rated
3.5.2	Construction Features		
	a) Enclosure		IP 23
	b) Insulation Class		Class H
	c) Terminal Box		Suitable for termination of Non-Segregated Phase Bus Duct (NSPBD).
3.5.3	Temperature Rise		Limited to Class F
3.5.4	Method of Neutral Grounding		415V SYSTEM - SOLIDLY EARTHED
3.5.5	Governing		Class A1
3.5.6	Excitation		BRUSHLESS
3.5.7	Winding and Bearing RTDs for generator		Yes
3.5.8	Battery Voltmeter		Yes
3.5.7	DG set Termination from Purchaser end		Sandwich Busduct
3.6	INSPECTION & TESTING		
3.6.1	At FACTORY Complete DG set		
	At 100 % Load		4.0 Hour
	At 110 % Load		1 Hour
3.6.2	At Site Complete DG set		
	At 100 % Load		8 Hours
	At 110 % Load		1 Hour
3.6.3	Diesel Engine		Type and Routine tests as per ISO 3036
3.6.4	Generator		Type & Routine tests as per IS4722/ BS5000
3.6.5	Exciter		Type & Routine tests as per IS4722/ BS5000
3.7	PERFORMANCE GURANTEES		

Sr. No	ITEM	UNIT	
3.7.1	Continuous Output (at site conditions)		Guaranteed capacity (kVA) provided by the Vendor during Bid, which shall be greater than 80% of the rated KVA.
3.7.2	10% Overload capacity		For One (1) hour out of Twelve (12) hours operation without overheating.
3.7.3	Fuel oil consumption at 50%, 75% and 100% Load		+ 3.0 % of data furnished by Bidder
3.7.4	Lube oil consumption		+ 5.0 % of data furnished by Bidder
3.7.5	Noise Level		75 dba at 1 m from surface of Acoustic Enclosure in all directions
4	'HIGH SPEED DIESEL STORAGE TANK		
4.1	Type		Horizontal welded
4.2	Installation		Under ground
4.3	Capacity		20KL-2Nos
4.4	Stored Fluid		High Speed Diesel
4.5	Material		MS -Sizes Bidder to Specify
4.6	Dimensions		As per IS 10987 with latest amendments - Detailed drawings to be submitted after award of contract
4.7	Type Of Nozzel / Manholes		Bidder to Specify
4.8	Notes for HSD Tank Works : - Tanks and holding down straps shall be corrosion free coated with red oxide and anti-corrosive paint. - Fill up from storage tank to the tanker bay should have NR valve and strainer - The complete design, fabrication and testing of the tank shall be as per IS 10987-1992 & CCOE. - The Dimensions of the Dish and Shell shall as per the storage capacity and as per IS 10987-1992. - The end plates shall be without joints or any welding. - Inside of Tanks should be coated with 2 coats of anti-corrosive rust preventive paint and Outside tank 2 coats of black bitumen paint - Tanks should be tested for water fill and pressure test as per IS 10987. - Should supply Inclusive of all required accessories for completing the installation		

TECHNICAL SPECIFICATIONS FOR
FOR HEATING VENTILATION AND AIR
CONDITIONING SYSTEMS

TABLE OF CONTENTS

1.	INTRODUCTION	3
2.	GENERAL REQUIREMENTS	4
3.	AIR / WATER COOLED CHILLER	24
4.	CHILLER PLANT MANAGER	68
5.	COOLING TOWER	100
6.	PRIMARY, SECONDARY AND CONDENSER PUMPS	106
7.	AIR HANDLING UNITS	119
8.	PRECISION AIR CONDITIONING UNIT (PAC)	130
9.	TWO STAGE EVAPORATIVE COOLING UNIT	138
10.	VENTILATION FANS	141
11.	OZONE GENERATORS	150
12.	DRY SCRUBBER	154
13.	PIPES AND FITTINGS	158
14.	AIR DISTRIBUTION SYSTEM	178
15.	INSULATION	194
16.	VARIABLE FREQUENCY DRIVES FOR HVAC SYSTEM	197
17.	HVAC – BUILDING MANAGEMENT SYSTEM	203
18.	MODE OF MEASUREMENT	215
19.	TESTING AND COMMISSIONING	219
20.	TESTING, ADJUSTING AND BALANCING	228

1. INTRODUCTION**1.1 SYSTEM DESCRIPTION**

- The goal of an HVAC system is to provide a healthy, thermally controlled and comfortable indoor environment with acceptable indoor air quality within the space of a building envelope by Designing and Planning a HVAC system for the Project with the objective that the system designed and built is cost-wise economical, energy efficient as well as simple, flexible with regard to its operation & maintenance.
- Also, the system must fuse and integrate fully with the building envelope for natural, normal behaviour as a whole, in disposing of the heat gains or offsetting the heat losses to maintain the desired environment inside the space.

1.2 SCOPE

- The purpose of this report is to give an overview of HVAC system for the Proposed building with 2 basement + G + 12 floors + Terrace Floor, at TIDEL Park in Madurai city.
- Apart from the above Security Block & STP shall also require HVAC Systems.
- All buildings shall be applying for LEED Platinum Certification. The Specifications are applicable as per the same.

2. GENERAL REQUIREMENTS

- The Conditions of Contract as described in this document are Intended to amplify the general condition of contract and shall be read in conjunction with Specification of work, drawing and all other document forming part of this contract wherever the context so requires.
- The following clauses shall be considered as an extension and not in limitation of obligation of the contractor. Wherever there is dispute in the terms, Specifications, Bill of Quantities, Drawings and Interpretation, the Architects / Project Consultants decision shall take precedence.
- Notwithstanding the sub-division of the document into separate sections and volumes every part of each shall be deemed to be supplementary to and complementary of every other part and shall be read with and into the contract.
- Wherever it is mentioned in the specification, that the contractor shall perform certain work or provide certain facilities, it is understood that the contractor shall do so at his own cost.

2.1 OBLIGATION OF CONTRACTOR

In addition, the obligations of contractor in fulfilment of HVAC work are stated below:

- Detailed engineering as specified
- Submission of Quality Assurance Plan
- Procurement, fabrication, and supply
- Inspection and testing
- Expediting and coordinating with other agencies
- Scheduling and Monitoring
- Erection, checking and testing.
- Pre-Commissioning
- Commissioning
- Carrying out performance tests to meet the specification requirement and to the full satisfaction of employer and as per Project consultant's / client's standards, procedures.
- Training the client's representative in the operation and maintenance of the plant and the system
- Providing guarantee.

- Final documentation and submission of as built drawings.
- Maintenance during guarantee / defects liability period
- Removal of scraps / wastages generated in process of work.

2.1.1 Checking up the equipment and other materials to ensure that the same are as per the specifications laid down in description of work and drawings and to make sure that they are in proper condition to be taken up for erection.

2.1.2 Drawing up a detailed time schedule and to organize the entire work in conformity with the time schedule.

2.1.3 Arranging for the procurement and ensuring availability at the site at the required time all the erection tools, necessary tackle, required for the erection work such as cranes, air compressor, welding sets, oxy-acetylene cutters, electric and pneumatic drills, steel wedges for levelling and grouting, scaffolding guy wire testing and cleaning equipment and all other construction equipment's necessary for proper erection.

2.1.4 Arranging for procurement and ensuring availability at site, at the correct time for all consumables, construction materials for erection work such as welding electrodes, oxygen, acetylene and other welding gases, greases, petrol, cotton waste and all temporary fastening such as tack bolts clips, cleats and other materials, chemicals for cleaning and such other materials as may be needed to execute the handling and erection works.

2.1.5 Engaging and allotting adequate number of engineers, erectors of all the required categories Supervisory, skilled, and unskilled labour for carrying out different items at different stages of the erection work.

2.1.6 Assembling and installing of all items of machinery / equipment at their proper places at the plant site. The erection work shall cover necessary operations such as, handling, sorting, stacking, unpacking, cleaning, assembling, bolting, welding, riveting, site fabrication, instrument cable laying and jointing, earthing, erecting, treatment for underground pipe protection, painting, thermal insulation, and manual / mechanical / chemical cleaning, testing and other operations, provision of inserts, embedded plates in walls / roof for erection of ducting piping etc.

- 2.1.7** Installation of all instruments measuring and controlling of the plant. All control wiring also forms part of erection work.
- 2.1.8** Checking up of each individual items of plant equipment as well as each pipeline, to ensure that the erection of these items has been properly carried out in conformity with the technical specification.
- 2.1.9** After all the installation and assembly works are completed, the entire plant assembly including the pipelines shall be checked up, by proper tests applicable to ensure that individual items of equipment, including pipeline have been properly installed.
- 2.1.10** Machines like compressors shall be checked up by actual working to satisfy that their alignment has been properly made and there are no mechanical faults.
- 2.1.11** Pipelines shall be checked up by hydraulic tests to make sure that all the items such as valves, flanges etc., have been properly fitted up to, that there are no leakages or wrong connection of interconnecting valves, pipes etc.
- 2.1.12** Similarly, all ductworks shall be tested as per SMACNA standards to ensure that air leakages rates are within the limits prescribed in the specification.
- 2.1.13** Instruments shall be checked up individually to make sure that they are in proper working order. The testing shall be in accordance with Indian Standards, accepted International Standards. All instruments used for testing and measurements shall be calibrated instruments conforming to National level standards.
- 2.1.14** The performance of the aforesaid services should conform strictly to the technical specification, which forms an integral part of this contract.
- 2.1.15** It is only after the entire plant assembly has been thoroughly checked up on the lines indicated above and found satisfactory that erection work shall deemed to be completed and the plant considered ready for commissioning.

2.1.16 The contractor shall submit 6 sets of 'As Built' drawings of services like ducting, piping, as well as equipment layout, wiring diagram etc. and a soft copy of the same on a CD.

2.1.17 Plant and equipment details shall also be prominently displayed in engraved plastic nameplates.

2.2 QUALITY ASSURANCE REQUIREMENTS

2.2.1 GENERAL

Quality assurance (Q.A) requirements form an integral part of the contract and all the contractors / subcontractors are required to comply fully, with the same.

2.2.2 SCOPE

The scope of QA requirements is as follows:

1. Preparation of a Quality Assurance Plan (QAP) by the Contractor for Material / Equipment.
2. Quality Assurance (QAI) and Quality Control (QCI) activities at site for all installations works including:
 - Testing and operation of the system complete as per the validation
 - Procedures and standards.
3. Documentation of the above as per the standards.
4. The requirements to meet fully the standards and validation procedures, protocols.
5. All QAP, QAI & QCI shall be submitted to Architect / Consultant for approval.

2.3 TENDER DRAWINGS:

2.3.1 The drawings issued with this Specification are for guidance of the TENDERER and show the approximate positions of all items of equipment, etc. The contractor to ensure that the equipment is located well within the proposed location.

2.3.2 The contractor shall prepare the shop drawings based on these tender drawings and the shop drawing shall be approved by the Consultant / Client. The tender has to ensure that their proposal will meet with all the current rules and regulations of the relevant local / national statutory.

2.3.3 The actual and final position of all items of equipment shall be determined at site after due co-ordination with other disciplines and approved by the Project Consultant / Client.

2.4 Supports From Building

2.4.1 All shop drawings shall be prepared in Auto CAD, scale not less than 1:100 on standard A1 size.

2.4.2 Before any work is put in hand, the Contractor shall submit two (2) sets of dimensioned drawings showing all details of the equipment, piping, wiring, ductwork, and materials etc for the review and approval of the Project Consultant. The Contractor shall not commence the works until the Drawings are reviewed and approved by the Project Consultant / Client.

2.4.3 Approval of Drawings by the Project Consultant / Client does not exonerate the Contractor from any responsibility under the Contract terms and conditions.

2.4.4 The detailed shop drawings, prepared to a minimum scale of 1:100 scale, plus necessary cross sections 1:50 scale, showing complete detail of each item of specially fabricated equipment shall be submitted to the Project Consultant / Client for his review prior to proceeding with fabrication. These Drawings shall be based upon the floor plans and the specifications. These drawings shall include accurately dimensioned details and locations of any special wall openings that are required where items of equipment extend through walls.

2.4.5 If early review is required, the Contractor shall advise the Project Consultant to this effect when submitting the drawings.

2.4.6 The Contractor shall forward six (6) sets of the reviewed approved shop drawings to the Project Consultant for distribution to various parties.

- 2.4.7** In case of existing building fitted with other services, the vendor shall prepare the shop drawings based on actual site condition and coordinated shop drawing must be prepared in line with existing services.

2.5 WORKING DRAWINGS

The Contractor shall at all times maintain on site, in good order and condition, a complete set of all drawings and documents necessary for the proper execution and checking of the works. These drawings and documents shall be made available on request to the Project Consultant / Client or his / their authorized persons on site. Any amendment shall be indicated on the Drawing, dated and signed by the authorised person in charge, with reasons stated if possible.

2.6 AS-BUILT DRAWINGS

- 2.6.1** The Contractor shall prepare two (2) sets of paper prints of the as-built drawings, showing accurate record of the work as installed by the Contractor and submit to the Project Consultant / client for approval.
- 2.6.2** When approved, the Contractor shall submit three (3) sets of paper prints, and one (1) soft copy.
- 2.6.3** As-installed drawings are for reference and record by the Project Consultant / Client. Such records shall include the preparation of properly dimensioned drawings showing the following:
- General arrangements of all services.
 - Cable routes, types of fixings, support and other particulars.
 - The detailed layout of all equipment, plant etc.,
 - Conduit pipe runs, duct work, etc.,
 - A system diagram giving means of identification, circuit labelling and mounting level of equipment, etc., provided under the subcontract.
 - Schedules of all equipment installed.
- 2.6.4** All drawings submitted by the Contractor shall have in the bottom right-hand corner in addition to the Contractor's name, title, scale and drawing number, the title of the project and subject of the drawings and as per the standards approved by the Project Consultant

2.6.5 The retention sum or final payment will not be released until all such drawings and records have been received and approved by the Project Consultant / Client.

2.6.6 One copy of the schematic drawing, isometric view of piping layout drawing showing all equipment, component, connections, etc. be framed and hung in the relevant Plant Room or location as directed by the Project Consultant / Client.

2.7 PRE-COMMISSIONING CHECKUPS

Prior to start-up of any unit, system, the contractor shall follow pre-commissioning check-ups. Each pre-commissioning check-ups reports shall be duly signed by project-consultant / client to proceed to the next step.

2.8 TESTING AND COMMISSIONING

2.8.1 GENERAL

- Testing shall mean providing that all the systems efficiently meet the performance specified while in operation. The systems shall be tested in the presence of the Project Consultant / Client. The contractor shall provide written requisition to the Project Consultant / Client to witness the test. The notice period shall be not less than 24 Hrs.
- The contractor shall arrange for representatives of his own and his Sub- Contractor to be in attendance during the tests.
- It shall be the responsibility of the Contractor to supply all necessary testing equipment including pitot tube and manometer, anemometer, newly calibrated pressure gauge, etc. and necessary skilled and unskilled labourers.
- Should anyone of the tests reveal a fault, the Project Consultant / Client will order that the fault be corrected and re-tested prior to acceptance. All fees connected with testing of equipment payable by Contractor to any of the relevant Government Authority shall be borne by the Contractor.
- In general, the testing procedure will be strictly as per QAI/QCI validation procedures, standards.

2.8.2 COMMISSIONING TEST

- The complete installation or any part thereof shall be tested, both before and after being commissioned to check the performance in operation. All fees connected with testing of equipment payable by the Contractor to any of the relevant Government authority or expert from the Supplier shall have been included in the Tender by the Contractor.
- The contractor shall be represented by a competent person approved by the Consulting Engineers during the whole of the period required for the tests.
- All materials and equipment supplied or erected under this Contract, which fails the tests, shall be replaced, or rectified at once by the Contractor without any cost to the Client.
- The Contractor shall supply all necessary instruments, apparatus, connections, skilled and unskilled labour required for the tests and the results shall be recorded and Project Consultants / Client make accurate records of all tests carried out and furnish the Consulting Engineers with four (4) copies of the test certificates and schedule of test results in approved form.
- The contractor shall prepare a detailed and comprehensive checklist for use during commissioning and testing. At least four (4) months prior to the start of commissioning, the Contractor shall commence gathering information required for this checklist. Two (2) months prior to the start of commissioning, the Contractor shall submit to the Consulting Engineer his proposed checklist for approval as under.
 - Ensure that all items that should be checked are complete in all respect.
 - Produce a permanent record of the commissioning checks-carried out.
- Accordingly, the checklist must be built from information contained in the Specification, from Suppliers, Sub-contractors and Contractor's installation and commissioning similar equipment and systems.
- The details of the checklist must be such that it can be completed with a reading or a tick, which means that every device listed, has been checked.

2.8.3 RELIABILITY TESTS AFTER COMMISSIONING

- The system installation shall be required to operate within the specified limits of its rating either continuously or intermittently as may be convenient without failure of any kind for a period of one (1) calendar month, before the provisional taking over certificate is issued. Final taking over and acceptance certificate will be issued only after 72 hours performance test in peak summer.
- Should any failure occur due to or arising from faulty design, materials or workmanship, but not otherwise sufficient to prevent the commercial use of the installation, the reliability test period of one (1) calendar month shall be recommended after the Contractor has remedied the cause of failure to the satisfaction of the Consulting Engineer. The onus of proving that any failure is due to any other cause shall rest with the Contractor.

2.8.4 TESTING AND ADJUSTMENT DURING THE MAINTENANCE PERIOD

In addition, the Contractor shall perform such test as may be directed at any time during the Maintenance period to satisfy the Project Consultant / Client that the installation complies with the specified requirements.

2.9 OPERATING & MAINTENANCE MANUALS

The Contractor shall prepare & submit an operating & maintenance describing the operation and maintenance of the whole system, for Consultant's approval. The O&M Manual shall include:

- Brief write up on the system installed.
- Operating instruction for all equipment
- Catalogues for all equipment including head/flow curves for all pumps with impeller size marked.
- List of recommended spares for 2 years maintenance.
- Schedule of recommended maintenance for various periods, daily, weekly, monthly etc.

On receipt of approval from the Consultant, the Contractor shall submit 3-sets of (O&M) manual, in a stiff covered ring binder. A soft copy in CD of the O&M Manual shall be also submitted.

Practical completion will be certified only after the receipt of the above operating manual by the Project Consultant.

2.10 IDENTIFICATION AND LABELING

The various parts of the works shall be properly labelled and identified. The Contractor shall carry out the following work:

2.10.1 Machine engraved traffolyte nameplates shall be provided to identify each equipment. Similar labels also be provided on ancillary equipment such as gauges, control Valves, Switches, Indicating lights, Push buttons, relays, and other Indicating devices.

2.10.2 Lettering shall be black on white background. Nameplates for major items of Equipment shall be engraved in lettering of at least 6mm. Labels identifying ancillary Equipment shall be engraved in lettering of at least 3mm.

2.10.3 Identification lettering shall be applied to all pipe work and to all conduit at the following spacing:

- For all concealed runs in walls or ceiling spaces, every 5 metres or at least once.
- For exposed runs, every 10 metres or at least once for each exposed section.

The identification shall consist of stencilled painted black lettering 25mm high naming the services

2.11 PLANT OPERATION

The Client shall have free and unrestricted use of the Contract works or any part thereof which the Project Consultant may deem suitable without any interference whatsoever from the Contractor and such use by the Employer shall not relieve the Contractor of any liabilities or obligations in regard to the Contract.

2.12 TESTING

- Routine and type tests for various items of equipment shall be performed at the Contractor's/Sub-contractors works and test certificates shall be furnished. The Client or his authorised representative reserves the right to be present during the tests.
- After notification to the Project Consultant / Client that the installation has been completed, the Contractor shall make under the direction of Project Consultant such tests and inspection as have been specified or as the Project Consultant shall consider necessary to determine whether or not the full intent of the specifications have been fulfilled and whether further tests shall be considered necessary. The Contractor shall bear all the expenses thereof.
- The contractor shall operate test and adjust all air-conditioning, ventilation and exhaust system units, fan motors, all air handling appliances provided in connection with the installation and shall make all necessary adjustments and corrections thereof including the adjustments of all regulating dampers. The detailed record of the result of these adjustments shall be furnished to and be subject to the approval of the Employer/consulting engineer.

2.12.1 PERFORMANCE TEST

- A performance test by keeping the plant / equipment running for a period of 72hrs shall be carried out in peak summer, peak monsoon, and peak winters periods. During the tests all necessary readings shall be taken hourly. From the readings so taken, the Contractor shall also establish the Plant, System Equipment capacity. The computed results shall tally with the specified capacities furnished with tender.
- The contractor shall install in the system temperature probes, flow meters, pressure gauges etc., to verify the capacity of the various equipment.
- All the test instruments labour, operating personnel, oil, refrigerant as required for these shall be furnished by the Contractor at his own cost.
- If the test do not show satisfactory result, the Contractor shall at his own cost, rectify/replace all defective installation or part thereof as directed by the Project Consultant / Client within one month. The decision of the Project Consultant shall be final and binding in this respect. Only after all these tests are satisfactorily completed and the defects found during these are rectified, the plant will be finally accepted.

2.12.2 TESTING GUARANTEE

- All equipment and space conditions shall be tested after carrying out necessary adjustments and balancing to establish the equipment ratings and indoor space conditions. At least Six sets of readings shall be taken daily for each item tested and submitted in the form shown separately. Instruments required for testing shall be furnished by the Contractor.
- All equipment shall be guaranteed for the specified ratings with a tolerance of 0% on the negative side.
- All equipment and the entire installation shall be guaranteed against defective materials and workmanship for a period as stipulated under Section-2 (Special Condition of Contract) from the date, the equipment, installation, and the complete system is accepted, and taken over by the client.

2.12.3 SYSTEM BALANCING

The contractor shall leave the system operating in complete balance with water and air quantities as shown on drawings. Set stops on all balancing valves and lock all damper quadrants in proper position. Secure all automatic damper and valve linkage in proper positions to provide correct operating ranges. Proper damper positions shall be marked on ducts with permanent indication.

2.12.4 REPORTS

Provide 3 copies of the complete balancing and testing reports to the Project Consultant and Client for further reference and record. Report shall be neatly typed and bound suitable for a permanent record. Report forms shall contain complete test data and equipment data as specified.

2.13 TRAINING

The Contractor shall conduct a training programme for designated Client's personnel. These courses shall be carried out during normal office hours and for the required duration. The date of commencement of training shall be mutually agreed upon and, in any case, shall be within one week of hand-over of installation.

- The training programme shall cover all operating and maintenance aspects of the system, inclusive of detailed explanation and demonstration of each and every piece of equipment and an overview of the system operation.
- The training programme shall consist of both handouts and classroom training, at the job site, or at location agreed upon by the employer.
- All instruction manuals, tools, transportation etc. associated with the training programme shall be provided by the Contractor. Such cost shall be deemed to have been included by the Contractor.

2.14 GUARANTEE

- The Contractor shall guarantee the inside conditions as stipulated elsewhere. In addition, the Contractor shall also guarantee that all equipment shall be free from any defect due to the defective materials and bad workmanship and that the equipment shall operate satisfactorily and the performance and efficiencies of the equipment shall not be less than the guaranteed values.
- The guarantee shall be valid for a period as stipulated under Section-2 (Special Condition of Contract) after taking over and any parts found defective shall be replaced free of all costs by Contractor. The services of successful Contractor's personnel if requisitioned by the client during this liability period, the same shall be made available free of any cost.
- The Contractor shall without any extra cost carry out all routine and special maintenance of the plant and attend to the defects that may arise in operations of the plant for the aforesaid period after the installation is taken over.
- One month before the end of the defects liability period, the Contractor shall notify the Client of the required inspections for all equipment's and facilities including specific energy consumption and system performance.

2.14.1 GUARANTEE PERIOD

- a) Guarantee Period starts from the date of successful commissioning of the system duly certified by the consultant / Project manager / client.

All snag points shall be completed within 30 days from the date of commissioning to the satisfaction of consultants / Project managers / client.

The guarantee period shall be extended for an equivalent period of delay of completion of snag points after 30 days from the commissioning date.

- b) Contractor shall depute dedicated person / team at client's place on full time basis with necessary tools and spares during guarantee period to maintain and operate the plant.

Regular and break down maintenance are part of the guarantee period maintenance and without extra cost.

- c) Response time : 2-4 hours
- Breakdown time : 12 hours for minor break down
- 24 hours for all Major Break down except compressor.
- Guarantee period : Refer Section-2 (Special Condition of Contract)

2.15 MAINTENANCE IN WARRANTY / GUARANTEE PERIOD

- Maintenance will consist of monthly maintenance and necessary adjustment and lubrication of the equipment by the Contractor's employee under competent direction and supervision. In addition to the monthly maintenance, special examination between regular intervals and emergency minor adjustment, call back services should be provided during the guarantee period.
- Parts that become necessary to be replaced due to normal wear and tear during the guarantee period will have to be replaced free of cost.
- In case of any defect or malfunctioning of the equipment during the period of maintenance, immediate attention must be ensured without claim to any extra amount, charges, or compensation.
- All the maintenance work will be performed during regular hours of regular working days and holidays as convenient to client with prior permission / intimation from client.

- The TENDERER shall furnish warranty for the entire system for a defects liability period (DLP) of 18 (eighteen) months after the final official take over date of the installation. This period shall include maintenance replacement of parts, regular periodic visit by qualified personnel of the CONTRACTOR and attending to emergency call at short notice.

2.16 CONCLUSIONS OF WARRANTY / GUARANTEE PERIOD

- Just before the expiry of the warranty / guarantee period of the Contract the Contractor shall carry out a complete system operability test on all the systems or sub-systems as called for in the Contract.
- The purpose of the test is to verify that the performance of all the systems, sub-systems in the Contract are in accordance to the specifications.
- All tests shall be carried out in the presence of the Project Consultant / Client or his / their representative.
- The warranty period is deemed to be over if the Client or his representative is completely satisfied with the system performance during the test.
- If any defects are found for non-performance of malfunction during the test, contractor shall replace / correct the system without extra cost.

2.17 ANNUAL MAINTENANCE CONTRACT

- The Contractor shall quote separately for comprehensive annual maintenance contract for full three years period after the Defect Liability Period (DLP). The Contractor shall bear the full responsibility for all kinds of maintenance, which includes periodic maintenance, as well as attending to all breakdown and emergency calls at short notice whenever called. During this three-year period the scope of annual maintenance contract includes repair and replacement of any or all parts as required. Besides, the replenishment of all consumables shall also to be included in the scope of annual maintenance contract.
- The Contractor shall furnish the list of recommended spares along with quantity and unit price schedule to the employer along with the bid. The Client reserves the right to order the required spares during the tenure or on completion of annual maintenance contract at the

quoted price which should be valid for the entire maintenance period i.e., three (3) years after DLP.

- After completion of guarantee period, client may award the AMC to any other agency or may call for tender as per the client's policy and choice.

2.18 COMPENSATION FOR SHORT-FALL IN CONTRACT RATINGS

2.18.1 RATINGS/CAPACITIES OF THE PLANT

- There shall be no credit to the contractor if the output of the plant is higher than the rated capacity. There will be zero percent (0%) tolerance for the rated capacity on the negative sides.
- During performance tests, in case of any shortfall in the contracted system/equipment capacity, the Contractor will be given an opportunity to make adjustments after which the performance test will be conducted again at the Contractor's expense. In case the equipment does not meet the contract rating, the equipment will have to be replaced at free of cost within a reasonable period of time as will be indicated by the Project Consultant / Client and as per Contract Clauses and penalty as per general terms and conditions shall be applied.

2.19 TAKING OVER CERTIFICATE

As soon as the works have been completed in accordance with the contract and have passed the tests on completion, as per validation procedures, the Project Consultant / Client shall certify the date on which the works have been successfully commissioned.

2.20 MOCK-UPS AND SAMPLES

The contractor shall carryout mockups of typical installations of services and common items of equipment as and when directed by the Project Consultant. Mock-ups shall be carried out to ensure proper installation and coordination with all services on site.

Upon approval, mockup shall be used as the basis of installation work for similar areas.

Samples of components, fixture, etc., shall be, submitted to the Project Consultant for approval before supply and installation of the component or work.

2.21 BRAND NAME/MAKE OF EQUIPMENT

The various components, equipment of the ACMV System offered should be only of the 'Brand Make/as indicated elsewhere in the specification to ensure fair evaluation of proposal. It is to be noted by the contractor that materials/equipment for which brand/make has not been specified, the contractor shall use only reputed makes. The contractor shall submit a list of such brands/makes for approval by the Project Consultant / Client.

2.22 SITE MANAGER & SITE ENGINEER

The Manager and Site Engineer posted at site shall have adequate experience for handling a job of this magnitude. The resume of the site manager & engineer shall be submitted along with the Tender for evaluation and approval.

2.23 CONSUMABLE MATERIALS DURING CONSTRUCTION, COMMISSIONING TESTING AND SUBSEQUENT WARRANTY PERIOD

The contractor shall supply at his own cost the following consumable materials as and when required.

- All oils and greases required for lubrication of compressors, fan bearings, motors bearings, pivots and other moving parts.
- All refrigerant required to replace refrigerant losses in the refrigeration system.
- All consumable, filter elements/rolls
- All electrical consumables such as carbon brushes for electric motors, fuses etc.
- All electric contact points required to replace worn electric contact points in switchgears, motor starter gears, electronic control gears and electric relays.
- All cotton waste, soap detergent and other cleaning materials required for cleaning purpose.

After every inspection and service, the contractor shall submit a written report to the Project Consultant with a copy to the Client.

2.24 PAINTING & LABELING**2.24.1 GENERAL**

- Unless otherwise specified, all exposed surfaces including trunkings and cable tray, ductwork, equipment etc., shall be thoroughly cleaned and painted.
- All ferrous metal surfaces without protective finishes shall be painted, exposed surfaces of moving parts, which shall be thoroughly oiled and greased as required.
- Non-ferrous surfaces shall be left unpainted unless called for in this specification as required by the Project Consultant for the purposes of colour coding and identification. Aluminium grilles and diffusers shall be powder coated with colour approved by Project Consultant.
- All bare surfaces requiring painting shall first be given a priming coat followed by an undercoat and two finishing coats.

2.24.2 PAINTING / FINISH

- Unless otherwise specified, all exposed surfaces including trunkings and cable tray, duct work, equipment, etc., shall be thoroughly cleaned and painted.
- All ferrous metal surfaces without protective finishes shall be painted, except surfaces of moving parts which shall be thoroughly oiled and greased as required.
- Non-ferrous surfaces may be left unpainted unless called for in this specification or required by the Architect for the purposes of colour coding and identification. Aluminium grilles and diffusers shall be powder coated with colour approved by the architects.
- All bare surfaces requiring painting shall first be given a priming coat followed by an undercoat and two finishing coats.

2.24.3 SIGN WRITING

- All major items of equipment shall be identified with approved names and / or numbers of suitable size in proportion to the size of the respective items.

- Pipelines shall be painted in contrasting colour directional arrows adjacent connections, valves and branches and at intervals of not more than 2.5 m. These arrows shall be 75 mm long on pipes up to 50 mm diameter and 150 mm long on pipes over 50 mm diameter.
- All stop valves and control valve the function of which are not obvious shall be provided with a non-corroding metal or laminated plastic identification tag. The tag shall indicate the service, and the area or items which the valve serves.

2.25 CONTROL OF NOISE & VIBRATION

- This section of the specification covers the supply, delivery, installation and testing of Noise and Vibration Control equipment to be used in the isolation of the various Mechanical equipment as called for in this specification.
- It is the intent of this specification that noise levels due to mechanical equipment and related services will be controlled to the design objectives stated herein, in all occupied areas. The requirements specified are considered to be the minimum precautions necessary to achieve these objectives. The entire installation shall operate without objectionable noise and vibration as determined by the Architect.
- The contractor shall examine all drawings and specifications including architectural and structural sets of working documents, before commencing any work on the project and shall immediately bring to the Architect's attention any characteristics or properties of the building or any other factors which, in his opinion, would jeopardize or nullify the attainment of the design objectives.
- The contractor shall guarantee that the complete plant and installation when operated within the design criteria shall acoustically perform to the noise criteria ratings specified.

2.26 MISCELLANEOUS EQUIPMENT

All equipment located in plant rooms above or under occupied areas and capable of producing noise or vibration shall be isolated from the structure. Acoustical isolation by neoprene/fibreglass, cork pads is required for tanks, electrical switchboards, etc.

2.27 PARTIAL ORDERING

The client Reserves the right to order the equipment and material from any and all alternates, and /or to order high side and /or low side equipment and materials or parts thereof from one or more tenderers through the Architect/Project consultant/ his representatives.

2.28 SOFT WATER AND POWER REQUIREMENT

The tenderer shall submit along with his offer requirement of soft make up water and power required for various equipment included in his system offered.

3. AIR / WATER COOLED CHILLER**3.1 AIR COOLED SCREW CHILLERS – FOR CRITICAL ROOMS**

Air Cooled chillers are planned for the critical areas across the building. This tapping shall be given as provision for each tenant with a capacity as mentioned in the critical room AC Heat load data sheet. Centralized chiller plant room space is planned along with all related space provisions for below spaces within the building.

Additional Chiller water tap off provision after isolation valve for critical room AC (working and standby) inside AHU room.

System configuration

Air Cooled Screw type with Single Compressor	150 TR (1W + 1S)
Temperature of chilled water entering Evaporator, ° F (° C)	54 °F
Temperature of chilled water leaving cooler Evaporator, ° F (° C)	44 °F
Chilled Water Flow Rate	2.4
Fouling factor (hr-sqft-F)/ Btu	0.0001 FPS Units
Number of Passes	2
Max. permissible pressure drop for Evaporator ft. WC	13
Refrigerant (No Chlorine)	R-134a / R 514A
Min. COP at AHRI conditions (100% load) including all losses like VFD & AHF	3.2
Min. IPLV	5.3
Noise level at 1.0 meter (dBA)	85

Power Supply, Volts/Hz/Phase for LT Chiller	415/50/3

3.1.1 SCOPE

The scope of this consists of but is not necessarily limited to the following:

- 3 Manufacture and supply of BMS compatible Air-Cooled Screw Chillers with associated motors and accessories.
- 4 All associated items herein to be supplied, delivered and installed.
- 5 Assembly of chiller components including connection of coolers, condensers, motors, compressors, purge system for low pressure machine etc. into complete refrigeration machines.
- 6 Provide manufacturer's factory representative's services, including coordination, and start-up and testing supervision.
- 7 Testing (at field), start-up supervision, training and providing necessary documentation and tools for operation.
- 8 Carry out performance test run at site.

3.1.2 TYPE & CAPACITY

The chiller shall be Air Cooled water chilling machine with single or multiple screw compressors and the actual refrigeration capacity and performance requirements at given design conditions of chilling machine shall be as indicated in drawings and Bill of Quantities.

3.1.3 GENERAL

Provide factory-assembled and tested, packaged, air cooled, liquid chillers consisting of screw compressors, compressor motor, air cooled condenser, condenser fans, evaporator, purge unit, refrigeration accessories, instrument and control panel including gages and

indicating lights, auxiliary components and accessories, and motor starters. Construct and rate units in accordance with AHRI Standard 550/590.

3.1.4 CASING

The casing and structure of the machine shall be of robust construction and weatherproof type. The panels shall be of heavy gauge, hot dip galvanized steel and they shall be assembled with folded joints. Where and if ferrous materials are used, whether for supporting structure or for any other system or for components, such materials / components / sections shall be given one coat of epoxy primer and two coats of epoxy paint of approved color.

3.1.5 COMPRESSOR

The compressor shall be a rotary screw type (min 2 compressors / machine) powered by a semi-hermetic / open drive. The compressor shall be suitable for use with refrigerant R134a. The compressor should be supplied by the OEM of chiller manufacturer. It shall be complete with suction and discharge shut-off valves, relief valve, oil filter, suction filter, muffler, dual manual reset type pressure state, oil safety switch, refrigerant suction and discharge pressure gauges, crankcase heaters and relays, direct coupled motor, oil separator, oil cooler. The compressor shall incorporate automatic capacity control feature. The unit shall be provided with slide valve unloading for partial load operations. The compressor shall have reducing capacity down to 25% of its full load condition. Motor shall be a gas-cooled, hermetically sealed, two pole, squirrel cage induction type. Further, compressors should be in unloaded condition during starting.

3.1.6 EVAPORATOR

- Provide evaporator of ASME U Stamped shell and tube type, seamless or welded steel construction, with cast iron or fabricated steel heads, integrally finned seamless copper tubes either smooth bore or internally enhanced, rolled or silver brazed into tube sheets. Space tube support sheets approximately 2.5 feet. Design, test and stamp refrigerant and

water side for 150 percent of the maximum design working pressure in accordance with ASME SEC 8. Provide machine welded to heat exchanger, with tapped drain and vent connections, mechanical joint connections arranged to permit inspection of tubes from either end without disturbing refrigerant and removable without disturbing water piping.

- Factory insulates evaporator surfaces and all other cold surfaces with two layers of 19mm minimum thick closed cell nitrile rubber insulation. Apply insulation so that all joints are staggered and no surface capable of causing condensation is un-insulated. Finish insulation with two coats of vinyl lacquer coating.
- Provide thermometer wells for temperature controller and low temperature cutout. Provide refrigerant chambers with baffles to distribute entering liquid and separate liquid from leaving gas. Provide evaporator suitable for circulation of the scheduled fluid quantities; with Scheduled pressure drops from inlet to outlet, including water heads as indicated; with sufficient eliminator area or other means to prevent liquid refrigerant carry over into compressor; and with a minimum water-side tube-temperature. Provide construction and materials conforming to ANSI B9.1 and ASME SEC 8.

3.1.7 AIR COOLED CONDENSER

- The condenser coil shall be made out of copper tube with aluminum fins / aluminum micro channel E-coat. The coils shall be sized so as to optimize performance with respect to air flow rate, pressure drop, condensing temperature, power consumption, etc. Thus, the values furnished for the parameters of the coil in the Schedule of Equipment shall be regarded as suggested values rather than specified values. The condenser coils shall provide with protective weld mesh to protect the fins from damage.
- The air-cooled condenser shall incorporate necessary number of propeller fans of adequate size to obtain the required air flow rate under operating conditions. The fan shall be balanced both statically and dynamically. The fan motor shall be of TEFC squirrel cage construction and to IP-55 protection. Wherever condensers with discharge of hot air in the vertically upward direction are involved, special care must be taken to ensure that the fan motors are suitable for such service. The motor shall be suitable for outdoor installation and also for location in the stream of hot air leaving the condenser coil. The fan motor sets shall be complete with protecting guards.

3.1.8 INTEGRAL CONTROL PANEL & CONTROLS

The control panel shall be provided in accordance with Electrical and Controls Requirements for Packaged Equipment. The unit control panel shall be equipped with the following:

- Electronic display to indicate evaporator, condenser pressures.
- Automatic positioning of inlet guide vanes to control outlet water temperature, limit motor current draw, limit evaporator refrigerant low temperature, and cut down high condenser refrigerant pressures. Inlet vane manual position control for service requirements.
- Motor current draw limit selector switch or key pad input for determining percent of full load current allowed, adjustable between 40 and 100 percent.
- One contact shall be provided for an all-inclusive failure alarm of the chiller. This remote alarm-annunciation contact shall be of fail-safe design (a normally open contact maintained closed in non-alarm conditions) so as to alarm upon the loss of control power or upon any other failures to the chiller. The dry contact is to be rated at 10 amps 120 Vac.
- A chiller operating control mode selector at the chiller control panel for off, local, and remote control mode selections. When in the remote run position, the chiller shall accept two 24 V DC signals, one to start and one to stop the chiller.
- When the chiller is commanded to run (either locally or remotely), the chiller will command the condenser water isolation valves to open and evaporator pumps to run via a dry contact closure (rated 10 amps, 120 V AC) located in the chiller cabinet. Pump control power will be provided from the individual MCC control circuits (24 V DC).
- Safety controls and interlocks for unloaded start, time between starts, refrigerant pressure and temperature, condenser water, and evaporator water flows, pressure switches and proof of status switches, oil pressure and temperature, surge protection, phase unbalance, phase reversal, electrical distribution protection, high current limit, and high motor temperature. Provide ride-through capability of 6 cycles at 30 percent voltage sag.
- Temperature sensors for the chilled water inlet/outlet lines shall be furnished, installed, and pre-wired with the chiller package.
- Operating hours and number of starts meters. This function may also be provided through the Integral Control Panel software.

- Field interface terminal strip for all field wiring.
- Chiller operating mode, chiller outlet water temperature and set point, current limit set point, and system diagnostic information displays.

The control system shall provide the following chiller control functions:

- Sequencing
- Lead / Lag
- Failure Recovery
- Diagnostics
- Operator Interface
- System Optimization
- Protection against single phasing and under voltage.

It shall be able to perform and program the running time for a minimum 3 months. It shall be capable of equalizing the total running hours of all the compressors housed in the unit. All safety and cycle shutdowns shall be annunciated through the alpha-numeric display and consist of day, time, cause of shut-down and type of re-start required.

Safety shutdowns shall include:-

- High oil pressure
- High compressor discharge pressure
- Low evaporator refrigerant pressure
- Motor fault
- Sensor malfunction

Cycle shut-downs shall include

- Low chilled water outlet temperature
- Low oil temperature
- Chilled water low flow or interruption or chilled water pump failure
- Power fault
- Internal time clock
- Anti-recycle

System operating information shall include:

- Chilled water inlet and outlet temperatures
- Evaporator and condenser temperatures
- Oil pressure and oil filter differential pressure
- Oil temperature and oil level
- Suction and discharge temperatures
- Slide valve position

Chiller package status like Start-up sequence status & Shut-down and operation status

- Number of compressor starts
- Total hours of operation
- Hours since last start
- Time of last start and time of last stop
- Compressor motor current
- Fault history
- Security access shall be provided to prevent unauthorized change of set points and to allow authorized local or remote control of chilling package.

The Control panel shall include machine protection shutdown with automatic reset when the condition is corrected for:

- Momentary power loss.
- Under/over voltage
- Loss of evaporator or condenser water flow

Over 100 diagnostic checks shall be made and displayed when a fault is detected. The display shall indicate the fault, the type of reset required, the fault, the time and date the diagnostic occurred, the mode in which the machine was operating at the time of the diagnostic and a help message. A diagnostic history shall display the last 20 diagnostics with the time and date of their occurrence.

3.1.9 Clear language Display Panel:

Factory mounted to the door of the control panel, the operator interface shall have a touchpad for operator input and a display screen. A chiller report, refrigerant report, compressor report, an operator configurable custom report, operator settings, service settings, service tests, and diagnostics may thus be accessed. All diagnostics and messages shall be displayed in "clear language."

The data contained in the chiller report, refrigerant report, and compressor report shall include:

- All water temperatures and set points
- Current chiller operating mode
- Diagnostic history
- Control Source (ie., local panel, external source, remote BAS)
- Current Limit set points
- Outdoor air temperature
- Saturated refrigerant temperatures and pressures
- Compressor starts and hours running
- Line currents
- Line Voltage
- Approach temperatures.

All necessary settings and set points shall be programmed into the microprocessor controller via touchpad of the operator interface. The controller shall be capable of receiving signals from a variety of control sources (which shall not be mutually exclusive – i.e., any combination of control sources can coexist simultaneously) and shall be capable of programming at the keypad as to which control source has priority.

Control sources can be:

The local operator interface (standard)

A 4-20 mA or 2-10 VDC signal from an external source.

3.1.10 INTERFACE WITH HVAC INTERFACE WITH CHILLER PLANT MANAGER

All necessary hardware / software to integrate the chiller panel to interface with Chiller Plant Manager system shall be provided free of cost by chiller manufacturer / supplier. For the

integration of Microprocessor Panel of the chilling machine interface with Chiller Plant Manager, an Interface Control Document shall be developed by interface with Chiller Plant Manager Contractor. It shall be responsibility of Chiller supplier to provide following to interface with Chiller Plant Manager interface with Chiller Plant Manager Contractor for preparing the interface.

- Hardware Protocol of Chiller Microprocessor panel.
- Software Protocol of Chiller Microprocessor panel.
- Communication structure relating to collection of message / event information.
- Description of the formatted packets / blocks of data which construct controller commands / responses.
- Written permission to interface with Chiller Plant Manager contractor to develop the interface without any financial implication.

3.1.11 ELECTRIC MOTOR

Motor shall be energy efficient and suitable for $415 \pm 10\%$ volts, 3phase, 50cycles AC supply. Hermetic / semi hermetic motors shall be gas cooled, two pole, squirrel cage induction types. In case of open compressor type motors shall be screen protected drip proof squirrel cage induction type. Motor shall be designed and guaranteed for continuous operation. Insulation of motors shall be 'F' class and IP55. Temperature rise of motor under rated service conditions shall not exceed 80 Deg C (by resistance method of measurement) over an ambient of 40 Deg C. the motor shall be provided with a combination of ball and roller bearing. Factory assembled Terminal box of sturdy construction shall provide enough space for terminating, connecting and earthing of XLPE insulated aluminium conductor cable. All terminal boxes shall be located at the same side of the motor and have terminal and cable glands suitable for the specified cables. The total efficiency shall include losses of the auxiliaries such as independent excitation, motor-driven fans, lube-oil pumps etc. Over voltage surge protection shall be provided to protect motor.

3.1.12 STARTER

Solid State starters shall continuously vary the voltage to maintain constant motor current during the start. The starting current should be smooth and continuous. Solid State Starters shall be provided with Silicon Controlled Rectifier (SCR) as the main power handling component of the solid state starter. Logic, overloads, and drivers should provide the controls that make decisions, provide safeties, and protect the motor and control the SCRs. Solid State Starter shall be housed in enclosure with hinged access door with lock and key. It may be unit mounted or free standing but has to be including all necessary interconnecting control and power cabling / wires.

- The Enclosure shall comply to the NEMA - 1 standards
- Input AC Voltage Tolerance: 415-V ac, plus or minus 10 % tolerance
- Minimum Efficiency shall be 95 percent at 50 Hz, full load
- The LCD / LED display indicator should indicate the status of On / Run / Over voltage / Line fault / Over current / External fault
- Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the status, frequency, current, alarm, voltage etc
- Automatic Reset and Restart: To attempt three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault.

VARIABLE FREQUENCY DRIVES FOR HVAC SYSTEMS

3.1.12.1 SCOPE

The scope of this section comprises the supply and installation of Variable Frequency Drives for equipment like AHUs, etc. conforming to these specifications.

3.1.12.2 GENERAL REQUIREMENTS

- This section describes the type of Variable Frequency Drive (VFD) for fan/pump speed control. The drive shall not be general purpose product, but a dedicated HVAC design. VFD shall be of variable voltage and variable frequency type, suitable mounting for variable torque application (fans).
- The VFD shall be tested to UL 508C. The appropriate UL label shall be applied or The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility

directive. The VFD should have UL, CUL, C-Tick approvals and confirm to Electromagnetic approvals compatibility directive. The VFD should have CE marking. Further, the VFD shall comply to EMC directive as per IEC 61800-3: 2004, category C2 or C3, on both conducted and radiated emission. Necessary Harmonic filters in built non saturating type DC links on both DC rails/DC reactors with matching inductance with load so that it reduces effect of harmonics and adds protection from AC transients. The drive shall be tested as per UL 508 and as per UL 508 and listed for 100 KA. Harmonic distortion shall be restricted to 5%. Suitable filters will be supplied with all VFDs. AC choke can be accepted however Choke design should ensure to avoid the voltage dip in the VFD due to the dip in the incoming power line and nuisance trip. VFD should operate in the voltage range specified in the tender.

- Generally, as DC choke is connected after the input diodes, the diodes may get unprotected from voltage transients. DC choke can be accepted however it shall ensure that the proper protection to diodes.
- The HVAC contractor shall collect the details of supply transformer rating, impedances, etc. from the Client to feed to the VFD.

3.1.12.3 TECHNICAL REQUIREMENTS

The drive should be suitable for three phase 415V, 50 HZ, AC supply, with a voltage description range of 380-480 V. The overload rating of drive should be 110% of its normal duty. The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable Frequency and voltage for controlling the speed of three-phase AC motors. The VFD shall convert 380 – 440 V, 3 phase, 50 Hertz utility power supply to an adjustable output voltage and frequency. The VFD shall continue to deliver full motor output voltage even if the supply is at (380 – 10%). The voltage to frequency ratio shall be suitable for fan control. It should not be possible to set a constant V/F ratio to prevent damage to connected equipment and to optimize energy usage.

- a) The VFD shall be capable of running with no motor connected for service functions. The VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor.

- b) The VFD shall be of sufficient capacity to provide a quality wave form so as to achieve full output of the motor, without causing additional heat rise. The VFD shall have following features:
- i. Minimum efficiency @ 100% load - above 96% and @20% load - 92%
 - ii. Efficiency of Variable frequency drive - Minimum 96% at full load Requirement
Displacement power factor-0.98.
 - iii. Rated input voltage 380V $\pm$ 10%, 3 phase, 48-62 + 1% HZ
 - iv. Working ambient temperature range – 10C to +40C, humidity to 95% RH.
 - v. Output frequency range – 0 to 1000 HZ.
 - vi. Output voltage range 0 to full mains input voltage, 3 phase even at (-) 10% of full mains voltage input.
 - vii. Connection of oversized motors within the current rating of the VFD shall be allowed.
 - viii. Output torque should be limited to 1.05 x F.L.T. to prevent damage to connected plant.
 - ix. The VFD shall accept 3 analog inputs of either 0-10V: 4-20mA as well as resistive inputs as a control signal.

The VFD shall have a dual DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics.

- a) The VFDs shall comply with the emission and immunity requirements of IEC 61800-3, Category C1 OR C3 with 50m motor cable (unrestricted distribution). The suppliers of VFDs shall include additional EMC filters if required to meet compliance to this requirement. The VFD's full load output current rating shall meet or exceed the normal rated currents of standard IEC induction motors. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 second while starting.

- b) VFD Shall have THD less than 5%. Active / passive filters must be used to achieve desired THD levels which will be in scope of Drive authorized supplier of OEM as per list of approved make.
- c) The VFD shall be capable of running the system at programmed lower speed at a lower frequency, in case of a phase loss. It should also be capable of sensing a loss of load (broken belt) and provide signal for the same.
- d) The VFD design shall comprise a diode input bridge, fixed voltage D.C. link section with both inductors and capacitors to form a filter and inverting bridge comprising I.G.B. T's (Insulated Gate Bipolar Transistors) and output inductors in the motor lines. All equipment must be housed within the VFD enclosure.
- e) The inverting bridge shall be controlled by a 32-bit processor and A.S.I. Cs (Application Specific Integrated Circuits) to produce a V.V.C. (Voltage Vector Controlled) P.W.M. waveform naturally resulting in full motor voltage and sinusoidal current of mains supply quality in the motor circuit. Other forms of current source or 8 pulse converters are not accepted.
- f) PID controllers shall be provided in the drive, allowing pressure or flow signals to be connected to VFD for a close loop control. The VFD shall be capable of powering a sensor cum transmitter supplied by others. The PID set point should be adjustable from VFD keypad, analog input, or communication bus.
- g) A programmable automatic energy optimization selection feature shall be provided as standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings. The VFD must be able to produce full torque at low speed to operate direct driven fans. Output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD.
- h) Galvanic isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete digital I/O shall include additional isolation modules.

- i) The VFD shall allow up to at least 100 meters of SWA (Single Wire Armour) cable to be used between the FC and the motor and allow the use of MICS (Mineral Insulated Copper Sheath) cable in the motor circuit for fire locations.

3.1.12.4 PROTECTIVE FEATURES

- a) Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.
- b) Protect VFD from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.
- c) The following user adjustable parameters shall be provided in the VFD-acceleration time, deceleration time, minimum frequency, maximum frequency. The drive shall be complete with hot pluggable local control panel with alpha numeric/graphical display of frequency, voltage, current, KWHr, running hours, active power, RPM, etc.
- d) In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping.
- e) The VFD shall have temperature-controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.
- f) Protect from output switching: The VFD shall be fully protected from switching a contactor / isolator at the output without causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans / pumps near the motor with VFD in ON mode.
- g) When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take appropriate protective action when one of the above situations is detected.

- h) The design shall include a full 4 term independent PID control (proportional integral derivable) as standard to provide closed loop control direct from a single transmitter without the need for external signal conditioning. The VFD shall not exhibit an inrush current when a 'start' signal is given and current must not exceed 105% at any time to prevent damage to connected equipment.
- i) The VFD design shall be suitable for either local or remote control, selectable. The VFD shall not be damaged if it is energized with a 'start' signal without a motor connected.

3.1.12.5 INTERFACE FEATURES

- a) The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System.
- b) Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes. All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.
- c) A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
- d) A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD. The VFD shall also have individual Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications.
- e) The VFD shall have 4 PID controllers which can also be used to control damper and valve positioners in the system and to provide setpoint reset. Four simultaneous meter displays shall be available. They shall be selectable from (at a minimum), frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, feedback signals in their own units, among others.
- f) VFD shall be programmable to display feedback signals in appropriate units, such as inches of water column (in-wg), pressure per square inch (psi) or temperature (°F). Examples can be room temperature in 0C, return air temperature in 0C, supply air

temperature in 0C, CO2 concentration in ppm, pressure in bar, differential pressure in PSI etc.

- g) VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the BACnet over IP. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

3.1.12.6 STANDARD INPUTS AND OUTPUTS

- 4-6 dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- Two/Four programmable relay outputs rated 250 V AC 1A/30 V DC 1A, for resistive, inductive, or capacitive load. Two programmable analog inputs shall be provided that can be either direct-or-reverse acting.
- Each shall be independently selectable to be used with either an analog voltage or current signal.
- A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.
- The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting,
- It shall be possible to command all digital and analog output through the serial communication bus.
- Modules may include such items as:
 - Additional digital outputs, including relay outputs
 - Additional digital inputs
 - Additional analog outputs
 - Additional analog inputs, including Ni or Pt temperature sensor inputs

It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD.

3.1.12.7 Standard programmable firefighter's override mode allows a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFD shall display FIREMODE whenever in firefighter's override mode. Fire mode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards, and conditions.

- i. A real-time clock shall be an integral part of the VFD.
- ii. It shall be possible to program unique events that occur only during normal workdays, there that occur only on non-workdays, and others that occur on specific days or dates. The manufacturer shall provide free PC-based software to set up the calendar for this schedule.
- iii. The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log.
- iv. The VFD shall include a Cascade Controller which allows the VFD to operate in closed loop set point (PID) control mode one motor at a controlled speed and control the operation of 3 additional constant speed motor starters.

3.1.12.8 COMMUNICATIONS & BMS COMPATIBILITY

- VFD should be able to provide following inputs/outputs-6 Nos Digital input,3 Nos relay output,2 Nos analog input,2 nos analog output. Standard EIA 485 (RS 485) communication port and capability with BMS over BACnet/MODBUS RTU protocols is required.
- The VFD shall include a RS-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:
- VFD shall have standard USB/USS/Modbus RTU/BACnet MS/TP port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system.

- The VFD shall have provisions for an optional 24 V DC back-up power interface to power the VFD's control card. This is to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost.

3.1.12.9 OPTIONAL FEATURES

All optional features shall be built and mounted by VFD manufacturer as an inbuilt factory solution. All optional features shall be UL listed by the VFD manufacturer as a complete assembly and carry a UL label.

3.1.12.10 SERVICE CONDITIONS

Ambient temperature at full speed, full load operation with continuous drive rated output current: -10 to 40°C for ratings up to 250 kW without derating and up to 60°C with de-rating:

- Relative Humidity: 0 to 95%, non-condensing.
- AC line voltage variation: + 10% of nominal with full output
- VFD Enclosure protection: IP 55, integral, with no additional cabinets
- Side Clearances: No side clearance shall be required for cooling.
- All VFDs shall be plenum rated.

3.1.12.11 QUALITY ASSURANCE

The VFD shall be fully tested at the manufacturer's works. The test certificates shall be submitted. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.

All optional features shall be functionally tested at the factory for proper operation.

3.1.12.12 INSTALLATION

- Install in accordance with manufacturer's instructions.
- Provide for connection to electrical service.
- Provide for connection of electrical wiring between starter and chiller control panel, oil pump and purge unit.
- Align chiller on concrete foundations, sole plates and sub-bases. Level, grout and bolt in place.
- Provide vibration isolation between unit and structural support.
- Provide evaporator connections to chilled water piping. On inlet, provide thermometer well for temperature controller, thermometer well and thermometer, nipple and flow switch, flexible pipe connector, pressure gage and shut-off valve. On outlet, provide thermometer well and thermometer, flexible pipe connector, pressure gage and shut-off or balancing valve as indicated on the drawings.
- Provide necessary auxiliary water piping for oil cooling units and purge condensers.
- Arrange piping for easy dismantling to permit tube cleaning.
- Provide piping from chiller rupture disc to outdoors. Size as recommended by manufacturer.
- Repair damages to factory finish (including insulation) up to time of acceptance by Owner.

3.1.12.13 PAINTING

The Chiller shall be finished with durable enamel paint. Shop coats of paint that have become marred during shipment or erection, shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the finish over the adjoining shop-painted surfaces.

3.1.12.14 NOISE LEVEL

Noise level of the chiller shall be ≤ 85 dB (A) 1 meter from equipment the sound levels shall be within the permissible limits and tolerances while measuring the performance in accordance with AHRI Standard 575-08, Method of Measuring Machinery Sound within Equipment Rooms.

3.2 WATER COOLED WATER CHILLING MACHINE:

Proposed Chiller capacity = 475 TR X 4Nos water cooled chillers (3 W +1 S)

Water Cooled Water Chilling Machine shall be complete with screw / centrifugal compressor, shell and tube condenser, chiller, machine mounted Variable Speed starter with active harmonic filters & microprocessor panel, all refrigerant piping & fittings, refrigerant feeding devices, valves, strainers, liquid-moisture indicators, suction line insulation, first charge of oil & harmonic filters, gas etc. All the components shall be mounted in an MS epoxy coated casing on robust framework fabricated using MS channels, angles and other sections. The Water chilling machines shall be mounted on vibration isolators.

Water Cooled Centrifugal type with Single/Dual Compressor	
Temperature of chilled water entering Evaporator, ° F (° C)	54 °F (12.22 °C)
Temperature of chilled water leaving cooler Evaporator, ° F (° C)	44 °F (6.67 °C)
Chilled Water Flow Rate	2.4
Fouling factor (hr-sqft-F)/ Btu	0.0001 FPS Units
Number of Passes	2
Temperature of condenser water entering condenser, ° F (° C)	86.9°F

Temperature of condenser water leaving condenser, ° F (° C)	96.9°F
Max. Condenser Water Flow Rate (US gpm / TR)	3.0
Fouling factor (hr-sqft-F)/ Btu	0.00025 FPS
Number of Passes	2
Max. permissible pressure drop for Evaporator & Condenser, ft. WC	13
Refrigerant (No Chlorine)	R-134a / R 514A
Min. COP at AHRI conditions (100% load) including all losses like VFD & AHF	6.5
Min. IPLV	9.1
Noise level at 1.0 meter (dBA)	85
Power Supply, Volts/Hz/Phase for LT Chiller	415/50/3

3.2.1 COMPRESSOR

The compressor shall be centrifugal type suitable for use with refrigerant R-134a / R 514a. The chiller can be of direct drive / gear drive and to be with multiple-stage compressor with control guide vanes. The compressor shall be incorporate automatic capacity control feature. The Compressor motor shall Refrigerant cooled, hermetically sealed, two-pole, squirrel cage induction type. In case of manufacturer offering Open motor design, suitable TEEAAC/ TEEWAC protection need to be offered for motor. The Compressor shall be designed for high efficiency and stability and shall be able to operate at all conditions from 100% down to 30% at constant condenser water entering temperature.

The compressor shall be of the own make of the chiller manufacturer and any third party / OEM sourced compressors for assembly is not acceptable.

3.2.2 Evaporator

- The water chiller shall be horizontal, shell and tube type, designed, constructed, and tested for the refrigerant specified in the tender specifications.
- The chiller shall be designed for a working pressure on the refrigerant side suitable for the refrigerant offered, and on the water side for 10 kg./sq.cm. Gauge.
- Evaporator shall be manufactured and tested in works as per asme standard and shall be asme u stamped.
- The end plates of chiller shall be made of carbon steel of thickness not less than 25mm.
- The shell of the chiller shall be made of carbon steel of thickness not less than 8mm with electric fusion welded seams.
- The tubes shall be of seamless, hard drawn copper with a minimum tube wall thickness of 0.71 mm for plain tubes & minimum 0.63mm at the root of fins.
- The tubes shall be internally finned for flooded type chillers as per manufacturer's design.
- The tubes shall be rolled into grooves in the tube sheets and flared at ends.
- Intermediate tube supports of steel or polypropylene shall be provided at spacing not less than 1250 mm for flooded type chiller to prevent sagging / vibration of tubes.
- The chiller shall be smooth finished with one coat of zinc chromate primer before the insulation is applied.
- The chiller shall be sand blasted from both inside (before insertion of tubes) & outside.
- The evaporator shell & tube inner surface area shall be thoroughly cleaned and free from any debris and metal particles before assembly.
- Connections and accessories

The flooded type of chiller shall be provided with the following connections and accessories wherever applicable:

- Refrigeration inlet and outlet connections.
- Liquid refrigerant float for level control/ expansion valve/ fixed or variable orifice.
- Pressure relief device.

- Charging connection with valve.
- Eliminator plate.
- Drain and vent connections with valves
- Water inlet and outlet connections
- Proper oil return system.
- Flow switch/pressure switch/differential flow switch/ flow sensor in the water line.
- Pressure testing
 - i. The chiller shall be tested in the works to 1.5 times the maximum working pressure for the refrigerant specified in the tender specifications, or 21 kg./sq.cm. (pneumatic), whichever is higher.
 - ii. The water side of the chiller shall also be tested to a hydraulic pressure of 10 kg./sq.cm. At the works.
 - iii. Pressure test certificates shall be produced in respect of each chiller.
- Evaporator shall need to be the shell-and-tube, flooded type designed on the refrigerant side. Shells shall need to be fabricated from carbon steel plate. Tubes offered are to be individually replaceable and shall be of externally finned seamless copper. The tubes are to be mechanically expanded into tube sheets. Eliminators are to be installed over entire length of the evaporator tube bundle. A multiple orifice control system shall need to be provided to maintain proper refrigerant flow. Condenser baffle is to be provided to prevent direct impingement of compressor discharge gas upon the tubes water side is hydrostatically tested at one and one-half times design working pressure, and the water side design pressure shall need to be for 150psig. The shell shall be of ms and the tubes of copper. Insulation shall be polyvinyl nitrile rubber with lamination on one side with 350-micron thick aluminium with pvc backing cladding. Thickness of the insulation shall not be less than 50mm thick having thermal conductivity max. 0.035 w/m. K at 10°C mean temperature. Density of insulation shall be minimum 50 kg/m³.
- The insulation shall be applied in such a manner that water boxes and covers be removable without damaging it. Insulation shall be applied on the complete chiller including condenser.

All the insulation joints shall be properly finished to get better aesthetic.

The evaporator and condenser shall need to be with standard nozzle in head connection.

All water boxes need to have 3/4-inch NPTI vents and drain connections are to be provided.

3.2.3 Microprocessor Panel

The machine mounted Micro-processor panel & starter panel shall need to provide control of chiller, operation and monitoring of chiller sensors, actuators, contactors, over load relays, single phase preventers, under / over voltage trip, on / off push buttons, auto manual switches to facilitate automatic operation through BMS System or for manual operation to facilitate remote starting & stopping of chiller packages, auxiliary contactors, etc. if any required. The panel shall incorporate the following:

Operating Data including:

- * Operating hours
- * Number of starts
- * Chilled water set-point.
- * Evaporator and condenser water flow status
- * Evaporator entering and leaving water temperatures
- * Evaporator saturated refrigerant temperatures
- * Evaporator approach temperature
- * Evaporator refrigerant pressure
- * Condenser entering and leaving water temperatures
- * Condenser saturated refrigerant temperatures
- * Condenser approach temperature
- * Condenser refrigerant pressure
- * Oil differential pressure

- * Oil tank temperature
- * Purge mode
- * Purge average daily pump-out time
- * % RLA per phase for motor
- * RLA per phase
- * Volts per phase
- * Power factor
- * kw,kwh
- * Frequency

The panel also need to contain the dedicated reports of Evaporator, Condenser, Compressor, Motor, Purge etc. Each report is comprised of a detailed listing of operational data relative to that chiller subsystem.

3.2.4 Control functions of the panel shall need to include:

- * Leaving chilled water temperature
- * Percent demand limit
- * Chiller water reset (based on return water temperature
- * Front panel control type
- * Set point source
- * Differential to start
- * Differential to stop

3.2.5 Status data function of the panel to include:

- * Waiting to start

- * Running
- * Run limit
- * Run inhibit (adaptive)
- * Auto
- * Free cooling (option)
- * Preparing to shutdown
- * Shutting down (post lube)
- * Stopped

3.2.6 Safeties to include:

Automatic safety shutdown for:

- *Low chilled water temperature,
- *Low evaporator refrigerant temperature
- *High condenser refrigerant pressure
- *Evaporator and condenser flow status
- *Low evaporator/condenser differential refrigerant pressure
- *Low oil pressure
- *Oil pressure overdue
- *High or low oil temperature
- *High bearing oil temperature (requires enhanced protection option)
- *High motor current
- *High motor temperature
- *Starter function faults

*Critical temperature and pressure sensor faults

The devices are of a latching trip out type requiring manual reset. Non-latching safety trip outs for operating conditions external to the chiller automatically permits unit to resume normal operation when condition is corrected. The chiller shall also need to monitor 3-Phase current to provide latching trip out protection from adverse effects of phase loss, phase unbalance, phase reversal, loss of phase reversal protection and electrical distribution faults (momentary power loss) by instantaneous trip out of motor.

3.2.7 Chiller Unit Control Features

The chiller unit control panel capabilities provide for the control/configuration interface to, and the retrieval/display of starter/ current related data. The chiller shall need to have minimum safety feature of

- * Motor overload protection.
- * Motor over temperature protection.
- * Phase loss, reversal, imbalance protection.
- * Overvoltage/under voltage protection.

3.2.8 Security

The Microprocessor shall need to have the feature to prevent unauthorized access to the chiller settings. The operator shall need to have option to choose to secure the operating settings with a password. Data and reports are to be accessed once the settings are locked out. The memory for the panel is needed to be of non-volatile type, so if power is lost, operating settings are retained.

3.2.9 Paint

All chiller painted surfaces are to be coated with a primer and an air-dry beige primer-finisher prior to shipment and the Chiller shall need to ship with neoprene isolator pads for vibration isolation.

3.2.10 VARIABLE FREQUENCY DRIVES FOR HVAC SYSTEMS

3.2.10.1 SCOPE

The scope of this section comprises the supply and installation of Variable Frequency Drives for equipment like AHUs, etc. conforming to these specifications.

3.2.10.2 GENERAL REQUIREMENTS

- This section describes the type of Variable Frequency Drive (VFD) for fan/pump speed control. The drive shall not be general purpose product, but a dedicated HVAC design. VFD shall be of variable voltage and variable frequency type, suitable mounting for variable torque application (fans).
- The VFD shall be tested to UL 508C. The appropriate UL label shall be applied or The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive. The VFD should have UL, CUL, C-Tick approvals and confirm to Electromagnetic approvals compatibility directive. The VFD should have CE marking. Further, the VFD shall comply to EMC directive as per IEC 61800-3: 2004, category C2 or C3, on both conducted and radiated emission. Necessary Harmonic filters in built non saturating type DC links on both DC rails/DC reactors with matching inductance with load so that it reduces effect of harmonics and adds protection from AC transients. The drive shall be tested as per UL 508 and as per UL 508 and listed for 100 KA. Harmonic distortion shall be restricted to 5%. Suitable filters will be supplied with all VFDs. AC choke can be accepted however Choke design should ensure to avoid the voltage dip in the VFD due to the dip in the incoming power line and nuisance trip. VFD should operate in the voltage range specified in the tender.
- Generally, as DC choke is connected after the input diodes, the diodes may get unprotected from voltage transients. DC choke can be accepted however it shall ensure that the proper protection to diodes.
- The HVAC contractor shall collect the details of supply transformer rating, impedances, etc. from the Client to feed to the VFD.

3.2.10.3 TECHNICAL REQUIREMENTS

- a) The drive should be suitable for three phase 415V,50 HZ, AC supply, with a voltage description range of 380-480 V. The overload rating of drive should be 110% of its normal duty. The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable Frequency and voltage for controlling the speed of three-phase AC motors. The

VFD shall convert 380 – 440 V, 3 phase, 50 Hertz utility power supply to an adjustable output voltage and frequency. The VFD shall continue to deliver full motor output voltage even if the supply is at (380 – 10%). The voltage to frequency ratio shall be suitable for fan control. It should not be possible to set a constant V/F ratio to prevent damage to connected equipment and to optimize energy usage.

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- c) The VFD shall be of sufficient capacity to provide a quality wave form so as to achieve full output of the motor, without causing additional heat rise. The VFD shall have following features:
 - i. Minimum efficiency @ 100% load - above 96% and @20% load - 92%
 - ii. Efficiency of Variable frequency drive - Minimum 96% at full load Requirement Displacement power factor-0.98.
 - iii. Rated input voltage 380V $\pm$ 10%, 3 phase, 48-62 + 1% HZ
 - iv. Working ambient temperature range – 10C to +40C, humidity to 95% RH.
 - v. Output frequency range – 0 to 1000 HZ.
 - vi. Output voltage range 0 to full mains input voltage, 3 phase even at (-) 10% of full mains voltage input.
 - vii. Connection of oversized motors within the current rating of the VFD shall be allowed.
 - viii. Output torque should be limited to 1.05 x F.L.T. to prevent damage to connected plant.
- d) The VFD shall accept 3 analog inputs of either 0-10V: 4-20mA as well as resistive inputs as a control signal.
- e) The VFD shall have a dual DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics.
- f) The VFDs shall comply with the emission and immunity requirements of IEC 61800-3, Category C1 OR C3 with 50m motor cable (unrestricted distribution). The suppliers of

VFDs shall include additional EMC filters if required to meet compliance to this requirement. The VFD's full load output current rating shall meet or exceed the normal rated currents of standard IEC induction motors. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 second while starting.

- g) VFD Shall have THD less than 5%. Active / passive filters must be used to achieve desired THD levels which will be in scope of Drive authorized supplier of OEM as per list of approved make.
- h) The VFD shall be capable of running the system at programmed lower speed at a lower frequency, in case of a phase loss. It should also be capable of sensing a loss of load (broken belt) and provide signal for the same.
- i) The VFD design shall comprise a diode input bridge, fixed voltage D.C. link section with both inductors and capacitors to form a filter and inverting bridge comprising I.G.B. T's (Insulated Gate Bipolar Transistors) and output inductors in the motor lines. All equipment must be housed within the VFD enclosure.
- j) The inverting bridge shall be controlled by a 32-bit processor and A.S.I. Cs (Application Specific Integrated Circuits) to produce a V.V.C. (Voltage Vector Controlled) P.W.M. waveform naturally resulting in full motor voltage and sinusoidal current of mains supply quality in the motor circuit. Other forms of current source or 8 pulse converters are not accepted.
- k) PID controllers shall be provided in the drive, allowing pressure or flow signals to be connected to VFD for a close loop control. The VFD shall be capable of powering a sensor cum transmitter supplied by others. The PID set point should be adjustable from VFD keypad, analog input, or communication bus.
- l) A programmable automatic energy optimization selection feature shall be provided as standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings. The VFD must be able to produce full torque at low speed to operate direct driven fans. Output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD.

- m) Galvanic isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete digital I/O shall include additional isolation modules.
- n) The VFD shall allow up to at least 100 meters of SWA (Single Wire Armour) cable to be used between the FC and the motor and allow the use of MICS (Mineral Insulated Copper Sheath) cable in the motor circuit for fire locations.

3.2.10.4 PROTECTIVE FEATURES

- Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.
- Protect VFD from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.
- The following user adjustable parameters shall be provided in the VFD-acceleration time, deceleration time, minimum frequency, maximum frequency. The drive shall be complete with hot pluggable local control panel with alpha numeric/graphical display of frequency, voltage, current, KWHr, running hours, active power, RPM, etc.
- In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping.
- The VFD shall have temperature-controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.

- Protect from output switching: The VFD shall be fully protected from switching a contactor / isolator at the output without causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans / pumps near the motor with VFD in ON mode.
- When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take appropriate protective action when one of the above situations is detected.
- The design shall include a full 4 term independent PID control (proportional integral derivable) as standard to provide closed loop control direct from a single transmitter without the need for external signal conditioning. The VFD shall not exhibit an inrush current when a 'start' signal is given and current must not exceed 105% at any time to prevent damage to connected equipment.
- The VFD design shall be suitable for either local or remote control, selectable. The VFD shall not be damaged if it is energized with a 'start' signal without a motor connected.

3.2.10.5 INTERFACE FEATURES

- The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System.
- Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes. All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.
- A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
- A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD. The VFD shall also have individual Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications.

- The VFD shall have 4 PID controllers which can also be used to control damper and valve positioners in the system and to provide setpoint reset. Four simultaneous meter displays shall be available. They shall be selectable from (at a minimum), frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, feedback signals in their own units, among others.
- VFD shall be programmable to display feedback signals in appropriate units, such as inches of water column (in-wg), pressure per square inch (psi) or temperature (°F). Examples can be room temperature in 0C, return air temperature in 0C, supply air temperature in 0C, CO2 concentration in ppm, pressure in bar, differential pressure in PSI etc.
- VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the BACnet over IP. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

3.2.10.6 STANDARD INPUTS AND OUTPUTS

- 4-6 dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- Two/Four programmable relay outputs rated 250 V AC 1A/30 V DC 1A, for resistive, inductive, or capacitive load. Two programmable analog inputs shall be provided that can be either direct-or-reverse acting.
- Each shall be independently selectable to be used with either an analog voltage or current signal.
- A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.
- The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting,
- It shall be possible to command all digital and analog output through the serial communication bus.

Modules may include such items as:

Additional digital outputs, including relay outputs

Additional digital inputs

Additional analog outputs

Additional analog inputs, including Ni or Pt temperature sensor inputs

It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD.

3.2.10.7 Standard programmable firefighter's override mode allows a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFD shall display FIREMODE whenever in firefighter's override mode. Fire mode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards, and conditions.

- A real-time clock shall be an integral part of the VFD.
- It shall be possible to program unique events that occur only during normal workdays, there that occur only on non-workdays, and others that occur on specific days or dates. The manufacturer shall provide free PC-based software to set up the calendar for this schedule.
- The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log.
- The VFD shall include a Cascade Controller which allows the VFD to operate in closed loop set point (PID) control mode one motor at a controlled speed and control the operation of 3 additional constant speed motor starters.

3.2.10.8 COMMUNICATIONS & BMS COMPATIBILITY

- VFD should be able to provide following inputs/outputs-6 Nos Digital input,3 Nos relay output,2 Nos analog input,2 nos analog output. Standard EIA 485 (RS 485) communication port and capability with BMS over BACnet/MODBUS RTU protocols is required.

- The VFD shall include a RS-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:
- VFD shall have standard USB/USS/Modbus RTU/BACnet MS/TP port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system.
- The VFD shall have provisions for an optional 24 V DC back-up power interface to power the VFD's control card. This is to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost.

3.2.10.9 OPTIONAL FEATURES

- All optional features shall be built and mounted by VFD manufacturer as an inbuilt factory solution. All optional features shall be UL listed by the VFD manufacturer as a complete assembly and carry a UL label.

3.2.10.10 SERVICE CONDITIONS

- Ambient temperature at full speed, full load operation with continuous drive rated output current: -10 to 40°C for ratings up to 250 kW without derating and up to 60°C with de-rating:
- a) Relative Humidity: 0 to 95%, non-condensing.
 - b) AC line voltage variation: + 10% of nominal with full output
 - c) VFD Enclosure protection: IP 55, integral, with no additional cabinets
 - d) Side Clearances: No side clearance shall be required for cooling.
 - e) All VFDs shall be plenum rated.

3.2.10.11 QUALITY ASSURANCE

- The VFD shall be fully tested at the manufacturer's works. The test certificates shall be submitted. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.
- All optional features shall be functionally tested at the factory for proper operation.

VFD Design Features

- * Simple modular construction.
- * NEMA 1 ventilated enclosure with a hinged, locking door.
- * Full motor voltage is applied regardless of the input voltage.
- * Soft start; linear acceleration; coast to stop.
- * Adjustable output frequency.
- * All control circuit voltages are physically and electrically isolated from power circuit voltage.
- * 150% instantaneous torque available for improved surge control.
- * Output line-to-line and line-to-ground short circuit protection.
- * Active harmonic filters to achieve

Digitally displayed on the panel: output speed in hertz, input frequency, output speed in rpm, input line voltage, output voltage, input line kw, output kw, input line amps per phase, average input line amps, output / motor amps average current in % RLA, load power factor, fault, VFD transistor temperature.

Environmental Ratings for VFD

- * 32F to 104 (0C to 40) operating ambient temperature
- * Altitude to 3300 feet (1000m), amperage de-rate of 1% per every 300 feet above 3300 feet
- * Humidity, 95% non-condensing
- * NEMA 1 rated

3.1.13 DETAILED DESIGN SUBMITTALS

- On the Award of Contract, the HVAC Contractor / manufacturer shall submit the following for approval.
- Shop drawing on each piece of equipment provided in accordance with the specification.
- Technical Data sheet, GA diagram, wiring diagram, foundation detailed drawings etc.
- Computer selections print out for the chilling unit offered and AHRI certified performance chart.
- Brief description of the system/equipment offered.
- Installation, Operation and Maintenance data sheet/manuals.
- Compliance statement with Tender requirements.

3.1.14 SITE ACCEPTANCE TEST (SAT) & ACCEPTANCE CRITERIA

- The vendor shall test and rate the chillers at site prevailing Site conditions. The testing shall be carried out in the presence of the Client / PMC / Consultant's representative. The following test shall be performed and the vendor shall rectify the defects/deficiencies to meet the specified capacity conditions for client's acceptance. The vendor shall provide necessary calibrated measuring instruments (whatsoever required) required for the testing.
- Functional test of the Chiller
- Capacity
- Power performance
- Engage a factory-authorized service personal to test the onsite performance of the Chillers. The Water chilling unit should be selected for the duty as specified in "the Tender". The water chilling unit should be selected for power consumption of not more than agreed IKW/TR, shall be tested at the prevailing building load and the condenser entry condition on the test date. The output data of the site test shall be compared with the AHRI certified software selection program simulated by the Vendor for the same conditions at site in presence of Client /PMC /Consultant. The Chiller performance shall be within the tolerance

permitted by AHRI. Contractor shall be responsible for ensuring the system performance as requested. If the power consumption in KW/TR of the water Chilling machine at site conditions is found to be more than that offered by the vendor, the vendor has to do necessary corrections in the Chiller or its parts to meet the performance free of cost. In the event that these revisions do not achieve submitted performance, Client reserves the right to reject the equipment or impose the following penalties.

3.1.15 WARRANTY

Provide 24 months warranty for parts, labor and refrigeration from date of handing over. The Chiller Warranty shall also inclusive of manufacturer's parts warranty.

3.1.16 CODES & STANDARDS

The design, materials, construction, inspection, testing and performance of chiller package shall comply with all currently applicable statutes, regulations, codes and standards in the locality where the equipment is to be installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility. In particular, the screw liquid chilling package shall conform to the latest edition of following standards:

ASHRAE 15 Safety Code for Mechanical Refrigeration

ASHRAE 23 Method of testing for rating positive displacement refrigerant compressors and condensing units.

ASHRAE 30 Methods of testing liquid chilling packages.

ASME SEC 8 Boilers and pressure vessel code

ANSI B 31.5 Code for Refrigeration piping.

AHRI 550 / 590 Water Chilling packages using the Vapour compression cycle.

AHRI 575 Standard for method of measuring machinery sound within an equipment space.

TEMA Standards of the Tubular exchanger manufacturers association.

NFPA 70 National Electrical Code.

3.1.17 AUTOMATIC TUBE CLEANING SYSTEM (BALL / BRUSH TYPE)

- **AUTOMATIC TUBE CLEANING SYSTEM**

It has to be factory fitted on chiller (Mandatory). Field supply ATC shall not be acceptable.

- **Ball Trap**

The ball trap shall be mounted between two flanges -(BS Table 10 E) IS2062 Grade B, 15 days 100lbs capacity, at the outlet line of the condenser. The casing shall be made from a MS material of IS2062 Grade B. The Ball trap should be sand blasted, followed by epoxy zinc rich primer and then epoxy based finished paint. The screen inside is made from stainless steel SS304L perforated metal sheet. All fasteners shall be of high-tension grade 9.8, 10.9, 12.9.

The Ball Trap should have pressure drop of less than 300 mm of WC. The body of the Ball trap shall be 2 inches higher in size as compared to the flange size or the pipeline size in which Ball trap must be installed. For example, if the pipeline size is 10 inches the Ball trap body should be of 12 inches.

- **Ball Collector**

The ball Collector shall be made of suitable size capable of storing all the sponge balls required and should be made from MS material of IS2062 Grade B. The Ball collector should be sand blasted, followed by epoxy zinc rich primer and then epoxy based finished paint. The Ball Collector should have a big sight glass for monitoring the balls. Toughened glass should be used and should be mounted by Allen key fasteners. All fasteners shall be of high-tension grade 9.8,10.9, 12.9.

- **Skid with Pumps & Valves**

The Skid should have pipe and flanges of MS material IS2062 Grade B. All welding of Skid shall be performed by Argon weld. The Skid frame should be of MS material of same IS2062 grade B. The Skid valves should be of diaphragm type or equivalent with all joints to be flanged and bolted. The valves used for injection and collection from respective chillers shall be of actuator type. All fasteners shall be of high-tension grade 9.8, 10.9, 12.9.

- **Control panel**

The Control Panel should be PLC based B/W LCD depiction of injection and collection cycle. The display should show system wise running along with pump running and off condition. The alarms and faults shall be indicated on the screen in case of any issue in operation.

- **Working Principle – Activity Sequence**

The operation is based on the circulation of the sponge ball through the condenser tube. The sponge ball must be pushed to the condenser inlet in not more than 5 seconds by a high flow of water(min.7L/S) which can be produced by a high-pressure source atleast 2 bar higher than the injection point at the condenser inlet. The source can be obtained by a single water injection pump in water injection system. Water injection system will be operated by a PLC controller which is pre-programmed to execute the cleaning process in two consecutive steps. They are ball injection cycle and ball collection cycle.

Ø **STEP 1:**

The PLC shall activate the cleaning process by detecting the on/off status of the corresponding chiller. If the chiller is on, the PLC shall command the control valves to open to manage the injection. The check valves shall be installed in the locations shown on the scheme above and as close as possible to the collector to ensure correct water flow direction during the injection cycle and the collection cycle.

Ø **STEP 2:**

The injection cycle, the PLC shall command the injection control valve to open for couple of seconds (the collection control valve kept closed in the cycle) and then close. The water pressure from the pump shall be used to push the water inside the injector to the collector and force all balls in the collector to the condenser.

Ø STEP 3:

The cycle shall be completed until the ball passing through the condenser where it should clean all the deposits on internal surface of the tubes. After leaving condenser the balls shall be trapped inside the ball trap unit.

Ø STEP 4:

- After the injection cycle is finished, the PLC shall command the collection control valve to open for couple of seconds (the injection control valve kept closed in the cycle) and then close. The negative pressure shall let the ball return from the ball trap unit back to the collector where the rinsing of the balls is carried out and then water is discharged to the outlet header of Condenser which goes to cooling tower. The ball shall wait in the collector until then injection cycle. The time of the collection cycle is normally pre-set at 27 minutes.
- A single pump should be on skid and shall be running during injection and collection cycles
- The pressure drop across ball trap shall not be more than 400mm
- The Valves shall give feedback to Control PLC of functioning.
- The Control PLC shall raise an alarm in case of any malfunctioning of system
- The total time of the whole cycle (injection and collection cycle) shall be 3 - 4 minutes
- A maximum number of 3 Condensers should be controlled by single skid and Control Panel. If the number of Condenser increases beyond 4, additional Skid with Control Panel should be considered and should be followed consequently
- The ATCS should be CE certified and OEM should confirm to the requirements of ISO 9001:2015. The ISO 9001;2015 certificate & CE certification on name of OEM should be submitted along with offer submission without fail.

3.1.18 CHEMICAL DOSING SYSTEM

Chemical Dosing System is a continuous monitoring & control of Industrial water system such as Cooling Tower boilers & Swimming pool water easy with a use friendly ATM style menu & large 16-line full graphic display that allows complete programming from the keypad. Different Level of Controller gives Techno-Economical comfort to customer.

3.1.19 LOGIC OF OPERATION:

- The main functionality of Cooling Tower Controller is to dose requisite quantity of chemicals in a predetermined proportion in to the cooling tower by controlling the dosing pumps.
- It receives a pulse type of signal from a flow meter installed in the makeup line. The pulse meter gives out a pulse every 1000 or 5000 or 10000 lit (depending on model and size). The controller counts those pulses and based on the proportion fed into the controller – controls the chemical dosing pump ON-OFF time.
- The controller is capable of controlling up to 3 chemical dosing pumps (optional default is 2 pumps)) and plus 2 biocide dosing pumps (Optional) with a 28 days timer, i.e. after every X No of days the biocide pump will start for certain time and will pump desired quantity of biocide into cooling tower system.
- The controller is also equipped with a conductivity monitor and controller, which is to be connected to a solenoid blow down valve. After setting the conductivity value – the bleed valve will open automatically if the conductivity limit is crossed. The bleed valve is closed automatically once the conductivity is lower than the set point. OPTIONAL – COC control – if a conductivity sensor is installed in make up line – the controller is capable of controlling COC by automatically selecting the Limiting conductivity, i.e. if you set COC = 6 and make up conductivity is 200 the blow down valve will open at 1200 cond. Value. If make up water conductivity changes to 300 the limit will be set to 1800 automatically. Thus the controller will control the COC.
- The main controller also has a auto pH controller which will control Acid dosing and Hypo dosing as per set limits of pH.
- The controller logs and stores on line data value (Conductivity& pH. and flow) every 2 minutes on it on board memory and the same can be downloaded for analysis through a USB port into a laptop. The controller stores data for previous 6 months in its on board memory.
- Controller has an optional Internet Modem – with a GSM SIM card. If this is installed – the controller then communicates with a server and a web site and all data is loaded on to a web site automatically

3.1.20 BENEFITS OF AUTOMATION**Water Saving**

Manual activity of blow down on time Ruther then TDS / Conductivity. Water loss in such blow down is always then the required. With control system solenoid valve will open only when the TDS / Conductivity of circulating water crosses the set point.

Chemical Saving

Water consumption in cooling tower is having direct relation with Evaporation Loss from the tower to achieve the desired cooling. The dosing of Corrosion and Scale inhibitor are based on actual water consumption after installation of V-Sense System. During lower heat load, partial running of Plant chemicals dosing also will reduced by V-Sense technology which will be net saving in terms of costly chemicals.

Optimum use of Biocide

Use of Oxidizing Biocide will be based on standard ORP. V-Sense improves disinfection by avoiding the detrimental side effects of mixing oxidizing and non-oxidizing biocides in the water (e.g. during bleed lock out).

Energy Saving

Biofilm and scale can drastically reduce the heat transfer performance in condensers. V-Sense technology saves energy by minimizing the risk of scale and microorganism accumulations.

Asset Protection

Fluctuations in ORP and pH can potentially damage condensers and heat exchangers. The precise Fuzzy logic of V-Sense ensures maximum protection to your equipment by consistent control to ORP and pH.

Green Technology

Through the combination of these advanced technologies, Ultima sets a high standard in environmental protection by minimizing water & chemical usage & discharge to the environment.

Analytics – Measuring & Assessing Results

It controlled will give the Tread of Water Parameter & Chemicals Dosing Pattern, which will give clear idea on Treatment Methodology.

Dosing of Chemical Directly from Carboys

It will be give feedback to dosing pump & hence no need to prepare the solution of chemicals, acid in drum. These dosing will be accurately controlled by controller. Output & hence plant person can dose chemicals directly from carboys with dosing pump.

4. CHILLER PLANT MANAGER**4.1 SCOPE****WATER COOLED CHILLED WATER PLANT CONTROL SYSTEM
DESCRIPTION (CPM)**

- This specification applies to the automation of a water-Cooled Chiller Plant, which has identical water-cooled Chillers in parallel, and with headered constant speed primary and headered variable speed secondary pumps.

The system description is as below:

- Pumping: Primary constant & secondary variable
- Parallel
- No. of zones: 1
- Chilled water supply demand: DP sensor based
- The chiller system manager shall be a Handheld Module based system. It shall combine the latest state of the art technology and shall be used to control & manage alarms and monitor building service installations.
- The system shall be logically structured into distinctive levels which are management level, automation level and field level.
- Each level shall be autonomous from the other. Peer to peer communication shall be possible on all system levels and the system design be modular in structure to allow straight forward extensions.
- The essential functions of the system are as follows: Centralized operation of the plant
(Remote control)
 - Early recognition of faults
 - Faults statistics for identification
 - Trend register to identify discrepancies, energy consumption, etc.

- Preventive maintenance and plant servicing
 - Optimum support of personnel
 - Control optimization of all connected electrical and mechanical plant
 - Prevention of unauthorized or unwanted access
 - Own error diagnosis integrated system
- The plant control system shall be supplied with all the hardware, software and programming required to control the required water-cooled chillers, cooling towers, primary / secondary (as the case may be) , condenser water pumps and all associated modulating / isolation valves etc. and up to 5 zone demand sensors (which can either be differential pressure or temperature sensors).
 - The quantity of chillers, pumps, valves, and demand sensors to be controlled shall be independently configurable (as per BOQ) on-site at the graphic user interface by selection from pull down menus, without requiring reprogramming or software download. All schematics, tables and menus in the graphic user interface shall show only the data and graphics corresponding to the selected configuration.
 - The plant control system shall be supplied with all the hardware, software and programming required to be seamlessly integrated with the reporting and remote read-write capabilities of the building automation system (BAS). The control system shall allow field adjustments of control parameters as described below.
 - To be quoted as a separate additional price: Preventative maintenance and service shall be available directly from the manufacturer. This service should include inspection and review of key components, assessment of operation conditions, control system tuning, software upgrades as they are released, back-up and secure storage of parameters and annual training for the Building Operators.

4.2 RELATED SECTIONS

- HVAC instrumentation and controls
- Chiller specification

- HVAC packaged pumping system
- BUILDING AUTOMATION AND CONTROL
- HVAC Bill of quantity
- HVAC Control Systems

4.3 STANDARDS REFERENCES AND QUALITY ASSURANCE

The Chilled Water Plant Control System shall be assembled with components that conform to the latest edition of the following as applicable:

ANSI – American National Standards Institute

NEMA – National Electrical Manufacturers Association

UL – Underwriters Laboratories

CSA – Canadian Standards Association

IEC - Degrees of Protection Provided by Enclosures (IP Code)

ASHRAE 90.1- [2013] - American Society of Heating, Refrigeration and Air-Conditioning Engineers – Energy Efficient Design of New Buildings.

The chilled water plant control system manufacturer must hold an ISO 9000

QA certification or approved equal

4.4 INSTALLATION AND HVAC CONTRACTOR RESPONSIBILITIES

The HVAC contractor is responsible for the following:

- Inspect interior and exterior and report any obvious damage or equipment shifting that may have taken place between the time the unit arrived on site and when in its final resting position. Mechanical installation of the CPM and mount in place. Install all life safety equipment as needed. All field electrical connections to the unit. Hook up electrical supply needed by the plant control system (including field sensors). Connect with the BAS and confirm that BAS is ready to send/receive commands to the control system.
- Field connects equipment including pressure/temperature sensors, flow meters and their associated wiring to the unit (Contractor to refer chilled water schematic for list field instruments) as required by device instructions, where necessary, calibrate all sensors and auto valves.
- Touch up and paint scratches and minor dents occurred during hoisting and rigging. Permits and inspections needed to start up the system.
- Start-up of system with the supervision of manufacturer personnel.

4.5 SUBMITTALS

- Provide a complete Chilled Water Plant Control System Submittal with all requirements as defined in the GENERAL requirements of these specifications. As a minimum, the Submittal shall include the following:
 - Dimensional drawings of the main components, also indicating weight and any special hoisting or working space clearances requirements.
 - Description of system operation
 - Electrical power and control wiring diagram
 - Control layout drawing with sequence of operation

4.6 OPERATION AND MAINTENANCE MANUALS

As a minimum, the Operation and Maintenance Manual shall include:

- a) System summary sheet
- b) Description of system operation, with equipment and control sequence of operation
- c) Electrical power and control wiring diagrams
- d) Installation and maintenance manuals from equipment manufacturers
- e) Snapshots of all graphic user interface screens, with description of all variables and recommended tuning values or tuning methods.
- f) Submittals and operation and maintenance manuals shall be assembled in a neat and orderly manner and bound in booklet form. Include a front page that identifies the job particulars followed by a table of contents.

4.7 START-UP, COMMISSIONING, WARRANTY AND SERVICE

- The start-up and commissioning will be by a HVAC contractor who is fully supported by respective OEM.
- Warranty period: the latest of [12] months from commissioning sign off or [18] months from shipment.
- The service shall include a web based self-serve interface.
- Included in the web interface shall be:
- Tracking of the project energy savings relative to the baseline:
- The baseline shall be calculated using measured equipment performance over a minimum of 90 days of continuous plant operation, or from building modelling software in accordance with ASHRAE Standard140
- Standard Method of Test for the Evaluation of Building Energy Analysis

Computer Programs.

- Summaries via the web shall also include ongoing tracking of the performance relative to the predicted performance. The predicted performance will be based on daily measured building loads and external

- temperature and humidity. The assessment of the chilled water plant will include kW draws from each of the following: chiller(s), chilled water pump(s), condenser water pump(s) and cooling tower fan(s)
- Financial savings shall be calculated using the INR/kWh rate provided by the customer. This shall include a provision for time of use “TOU” rates (if applicable) by applying the specific TOU rate to the savings per hour as measured and reported in the ongoing diagnostic service. Savings in energy shall be the difference between the actual chiller plant kW draw per hour compared to the baseline adjusted for the prevailing weather and building load to match that hour of measured consumption.
- The service shall include 4 (quarterly reports) that at a minimum include:
- Summary of plant efficiency profiled against operating loads
- Detailed chart of how the chilled water plant performed relative to the predicted performance.
- The predicted performance will be calculated as outlined above
- The report shall summarize of key findings regarding overall performance
- Recommendations to improve the efficiency of the overall chilled water plant based on the analysis
- The detailed quarterly report will be delivered electronically no later than 6 weeks at the end of the preceding quarter.
- Daily summaries shall be generated and provided in email or other electronic notification that summarize the actual measured efficiency of the chilled water plant relative to the predicted efficiency. The predicted efficiency shall be based on the outdoor weather conditions for the day (temperature and humidity in combination with the building load).
- An automatic email summary of notifications shall be customizable to fit the project specific instrumentation selected by the owner. Daily email notifications shall include options for the following:
- Chiller high evaporator approach (only available for Chillers with Serial communication)

- Chiller high condenser approach (only available for Chillers with Serial communication and Outside Air Temperature sensor is provided by others)
- Chiller excessive run hours
- Unstable chilled water supply
- Low delta t syndrome
- Chiller efficiency below expectations
- Pump rpm different than recommended
- Compressor excessive vibration (available if vibration sensors installed are provided by others)
- Pumps excessive vibration (available if vibration sensors installed are provided by others)
- High pump kW relative to chiller kW

4.8 PRODUCT

i) MANUFACTURERS

Acceptable Manufacturer: As per the approved make list of the chiller OEM.

Substitutions: Not permitted

ii) HARDWARE

CHILLED WATER PLANT CONTROL SYSTEM AND ASSOCIATED EQUIPMENT

- The chilled water plant control system shall be a stand-alone system capable of operating independently of the Building Management System (BMS), and at the same time capable of receiving remote instructions from the BMS.

- The plant automation shall be performed solely by the PLC along with the handheld device and the PC shall not be required for plant operation, other than initial setup or configuration.
- The chilled water plant control system shall include a combination of handheld device-based and PLC controller.
- The chilled water plant control system shall have an internal circuit breaker and run on 100-240 Vac /1Ph/50-60Hz power supply.
- 10.4" back-lit touch screen LCD panel
- Operation temperature range: 0°C - 50°C (32°F-122°F) (must not be exposed to direct sunlight)
- Operation humidity range: 5% - 95%, non-condensing
- Power supply: AC 100-240V, 500 W
- Unit must be complying {UL mark, FCC compliant} or {CE mark, EN 61000-4-3 compliant}
- The control system shall have a key lockable as {NEMA 12} or {NEMA 4} or {IP54} or {IP55} rated cabinet. All operator interface control switches, indicators and displays shall be physically separated from any field terminations. Manual backup control switches and indicators must be protected from unauthorized operation by a key lockable door.
- The plant control system shall have Hand-Off-Automatic (H-O-A) control for each variable speed primary pump. The virtual H-O-A switch shall be accessible through the touch screen display, and in Hand mode, the control system shall allow the pump speed to be manually set and changed.

iii) SCREEN

- The chilled water plant control system shall include a back-lit touch screen color display operator interface of at least 10.4" and show active-element schematic displays with links to sub-menus for status reports, data, and setup menu options. Keypad based interfaces, LCD readouts, and LED displays will not be accepted. The control system shall perform online self-diagnostic testing of the CPU(s), RAM, and flash memory. No data shall be lost during power supply interruptions.

- The control system shall be self-prompting. All messages shall be displayed in plain English, French, Spanish, Chinese and Portuguese. The operator interface shall have store in memory at least 50 faults and be able to recall them on the screen, on-screen help functions, and separate user screens for:
 - i. Chiller configuration
 - ii. Pump configuration
 - iii. Differential pressure, flow, and temperature sensors' setup
 - iv. Zone setups (including calibration of differential pressure/temperature sensor range)
 - v. Alarm history and event review
 - vi. Display of zone status, chiller status, pump status and system status
 - vii. Factory default / commissioning setup data
 - viii. Best Efficiency Point speed setup
 - ix. PID control parameters setup
 - x. BAS communication setup
 - xi. System schematic(s) showing chillers, pumps and valves operating parameters and sensors readings

iv) INSTRUMENTATION

- The chilled water plant control system shall provide the following remote mounted transmitters and sensors to be installed and wired back to the central plant control system by the HVAC contractor:
- Temperature sensors, pressure sensors and flow meter shall be installed by the HVAC contractor as indicated in the shop drawings to modulate the chilled water system.
- Temperature sensors shall be self-contained RTD type temperature transmitter with a temperature range of (-400 to 1076°F) (-240 to 580°C) for chilled water systems designed to meet NEMA-4X (IP66) construction. The temperature probe shall use a platinum, wire wound, sensing element in a 316SS sheath, spring loaded and inserted into a ½" NPT

stainless steel thermo well. The thermo well shall penetrate one-half the pipe diameter. The two probes of the supply and return temperature sensors shall be matched pair.

- Sensors shall not be locally adjustable. The accuracy of the temperature sensor shall be 0.5% of span and shall be calibrated and traceable to NIST. The temperature transmitter shall receive its power input and send its current output, 4-20 mA, over the same pair of low voltage wires. Sensors shall be
- mounted such that effects of radiation from heating elements are minimized and rapid response to changing temperature is achieved. The stability of the transmitter/probe assembly shall be $\pm 0.001\%$ of span/100 Ohms of lead resistance. Wiring installed by the contractor between the control system and
- the transmitters shall be 2-wire, shielded, twisted cable (or equivalent) and shall not be placed in conduit containing wiring for alternating current. Supply and return temperature sensor shall be field installed and wired by the contractor between the chillers and the bypass line.
- Pressure sensors shall be complete, self-contained, variable capacitance type, stainless steel construction differential pressure transmitters designed to meet NEMA-4X (IP66) construction and provide a 4-20 mA signal output. The accuracy of the pressure sensor shall be 0.5% of span including linearity, hysteresis, and repeatability. Wiring terminals and electronics shall be in separate compartments, so the electronics remain sealed during installation.
- Reverse polarity protection shall be included to keep wiring mishaps from damaging the transmitter. Wiring between the control system and the transmitters, provided by the installing contractor, shall be Belden 9320, 2 wire, shielded twisted cable (or equivalent) and shall not be placed in conduit containing AC electrical wiring. Pressure switches shall have adjustable ranges and adjustable differentials to suit the application. Pressure sensor shall be field installed and wired by the contractor.
- The flow sensor shall be a high precision magnetic flow meter with no moving parts. Paddle and turbine type sensors will not be accepted. The sensor shall have a maximum operating pressure of 300 psi, operating temperature range of 5°F to 158°F. Accuracy shall be within

0.5% of actual reading at the calibrated typical velocity and within +2% of reading over 200:1 turndown (from 0.05 to 10 m/s). Provide certificate of calibration with each flow sensor.

- The sensor shall have integral 4-20mA analog output linear to within +0.1% of calibrated span for connection to the control system. The flow sensor shall be constructed of stainless steel with NEMA 4 (IP65) protection. Contractor shall supply hot tap installation, in order to be both insertable and removable
- through a ball valve when the pipe is under pressure. Flow meter shall be field installed and wired by the contractor. The sensor shall be field mounted and wired in accordance with manufacturer's instructions.

v) SOFTWARE

Capabilities: The chilled water plant control system software shall be preprogrammed to perform, but will not be limited to, the following:

- i) Manual or automatic control system
- ii) Schedule start/stop
- iii) Duty cycling
- iv) Automatic lock-out of malfunctioning equipment
- v) Backup sequences of control for any sensor failure
- vi) Automatic temperature control
- vii) Pump control to satisfy zones demand
- viii) Control sequences for dedicated and for headered pumps
- ix) Control sequences for dual dedicated pumps with options for duty/duty, duty/standby and lead/la operation
- x) Optimized sequencing of headered pumps
- xi) Control sequences for Sensor less™ and zone sensors pump speed control options
- xii) Zone setpoints reset based on most open load valve
- xiii) Optimized sequencing of chillers based on cooling demand
- xiv) Sequencing of chillers override to prevent exceeding their kW rating and FLA
- xv) Supply temperature set point reset
- xvi) Load shedding / Demand limit
- xvii) Scanning and alarm processing

xviii) Graphic screen reporting

xix) Trend Logging

- User Friendliness: The chilled water plant control system software shall be easy to operate. Operators shall be able to perform the following operations after one day of training:
 - View systems parameters
 - Select relevant screens, systems and points
 - Turn on and off controlled points manually
 - Acknowledge alarms
 - Log trend data
- Input/Output: A complete point schedule shall be provided detailing analogue and digital input and output point description, functions, types and any special requirements. The control system shall be capable of accepting and processing appropriate signals (Differential Pressure, Temperature, or Flow) for the following dedicated terminal blocks:
 - **Instrumentation control point shall be as per BOQ/ chilled water schematic.**
 - **In addition to above following accessories to be provided.**
 - 1 serial RS485 port and 1 Ethernet port for communication with the BMS,
 - 1 serial port for communication with the VFDs,
 - 1 terminal block for power supply 100-240 Vac/1 phase/50-60 Hz
- Trending and Reporting Capabilities: The control system shall provide a data-logging feature with 1 year of data at 5 minutes intervals and shall be capable of displaying the alarm history on its graphical touch screen display. The data must be easily downloadable monthly in a csv format file.
- The chilled water plant control system shall display live and trend data on demand. The control system shall provide graphic screens of system schematics.

- Communication Protocol: The chilled water plant control system shall be able to communicate with the Building Automation System over one of the following & not limited to : Modbus RTU, Modbus TCP, BACnet MS/TP, BACnet IP,
- The plant control system shall allow changes to the field the network address of equipment it communicates with (chillers, variable speed pumps, etc.) and its own address on the interface it communicates to the BAS. Network addresses cannot be hard coded.
- Remote Access: The chilled water plant control system shall include webserver functionality and be accessible through an internet TCP/IP internet address with read/write functionality. This access shall allow the relevant staff to:
 - Remotely view all screens available at the local graphic user interface (GUI), with the same functionality. I.e.: view plant status, view and modify parameters and setpoints, override equipment and navigate screens.
 - View all available live and historic data
 - Receive alarm messages, automatically processed and conveyed via the network and via email.
 - Upgrade the plant control system software from the remote stations. Such remote upgrading shall not interrupt the plant operation and shall not require local intervention, (like locking equipment in manual).
 - Remote manual override by the BAS shall be possible for the following equipment settings:
 - Control System ON/OFF
 - Plant Mechanical mode/Stand-by mode
 - Alarms: Alarms shall be generated, and the alarm messages shall be displayed in clear textual form on the screen, until it is acknowledged by the operator. Alarms shall include but not limited to the following list:
 - System fault alarms
 - General alarm
 - Pumps run feedback alarms

- Chiller alarms
- Pump alarm
- Drive fault alarms
- No flow alarms
- Zone/sensor alarm
- Drive communication alarm
- potential free contacts shall be provided for general alarm, hooter/ buzzer, communication alarm and general sensor alarm
- Safety Features shall include but not limited to the following list:
 - Auto omission of pump in case of pump failure
 - Auto omission of chiller in case of chiller failure
 - Auto omission of zone/sensor in case of any zone senso
 - Backup sequences in case of flow sensor failure, temperature sensor failure, and all zone sensors failure.
 - Sequencing of chillers to prevent the flow through the running chillers to exceed their rated maximum (or fall below their minimum), or to exceed the power consumed by the running chillers to exceed their rated maximum
 - Program distributed over several PLCs in such way that if those handling the most complex functions and remote communications fail, the lower-level ones will keep the plant running with simpler logic.
 - Indication of any Failure (or) malfunctioning in the touchscreen screen user interface, the remote access screens, in the BAS communication and via email to the operator.
 - Pumps status confirmation with differential pressure switches
 - Remote stop for emergency shutdown.

- Graphics shall be included for ease of system operation. Graphic screens shall include, but will not be limited to, the following:
 - System schematic
 - Chiller system schematic
 - Building loop schematic
- Access Security: The control system shall have at least three levels of password security:

one level for field adjustable parameters, a second for factory/commissioning setup parameters and a third for BAS communication commissioning.

4.9 Sequence of Operation:

- All plant control system settings, including the number of chillers and pumps, as well as how they are connected (headered or dedicated) can be modified at the graphic user interface (GUI) after entering the appropriate password.
- The plant control system determines the most efficient combination of operating pumps, and pump operating speed based on the zone differential pressure, zone Temperature sensor signals and/or Parallel Sensor less as per the field adjustable configuration.
- The control system shall continuously monitor all zone signals to determine an active control zone. Use of a multiplexer for multiple sensor inputs is not acceptable.
- The control system shall respond to the most dissatisfied zone by increasing either, the number of operating pumps, or the pump speed.
- The control system shall automatically disable any zone differential pressure or Temperature signals that are not within limits and alert the operator of a possible transmitter failure. If system found all differential pressure/temperature sensors failure in the building, the pump speed will default to a pre-defined percent of full speed (factory default loaded as 95% of full speed).

- The pump logic control system shall sequence the pumps based on a field adjustable interval of operating hours with a “bump-less” transfer algorithm. The control system incorporates an adjustable PID control loop and embedded logic to prevent hunting.
- The control system shall determine the optimum numbers of chillers to operate based on the plant load (thermal energy rejected) or to prevent the flow through the running chillers to exceed their rated maximum (or fall below their minimum), or to exceed the power consumed by the running chillers to exceed their rated maximum, or to prevent the supply temperature to exceed the setpoint by a field adjustable offset.
- For each chiller the control system has an adjustable field to enter its capacity. The plant load (in Tons and %) is displayed on the touch screen display and used to Stage on and Off the chillers, in conjunction with the other conditions explained in the previous paragraph.
- The control system shall rotate the Lead chiller on a field adjustable interval of operating hours. Should any chiller fail, the control system will trigger an alarm on the touch screen display and remove said chiller from the auto sequence and rotation.
- The control system shall be capable of interfacing with up to 8 isolation valves (used when the chillers & condensers are headered). A digital output opens and closes the valves, and a digital input provides open/close feedback.
- Automatic operation mode: When the chilled plant control system is in automatic operation mode, the chiller plant is automatically started, and all equipment is sequenced and modulated entirely automatically to meet the current cooling load with optimum operating efficiency.
- Manual operation mode (for commissioning): When the chilled plant control system is switched to the manual operation mode by the operator, there is no automatic operation or sequencing of any equipment and operation of chillers, chilled water distribution pumps, condenser water pumps, cooling towers and cooling tower fans continue at the same status when operation mode was switched to manual mode, until further changes by the operator. When operation mode is switched back to auto, the automatic operation mode is restarted.

- The chilled plant control system shall be capable of providing parallel pump station control for speed and sequencing of pumps using one or more of the following methods:
 - i. Remote zone differential pressure (DP) sensor
 - ii. Local pump station DP sensor with simulated quadratic control curve
 - iii. Zone returns temperature sensor
 - iv. Building return temperature sensor and/or Sensor less pump speed and parallel Sensor less pump control.

4.10 EXECUTION

a) ELECTRICAL WIRING AND INSTALLATION

The wiring for data communication between sensors, control systems and valve actuator shall be shielded so as not to be susceptible to electrostatic, magnetic, mode and cross talk noise. Electrical wiring shall conform to the requirements of the electrical services section of the specifications and the local electrical code.

4.11 TESTING

Upon completion of all systems startup and checkout procedures and while the mechanical systems are being monitored and controlled in a “normal operating” condition, the manufacturer and the facility personnel shall jointly demonstrate the performance of the complete system to maintain flows, temperatures, levels, and pressures for 7 days, with no alarms. The test must meet the building’s design requirements to be considered passed and acceptable. Any failures or alarms shall require the test to be restarted.

4.12 CALIBRATION AND COMMISSIONING

- The chilled water plant control system shall be commissioned and fully operational after delivery to the site at the practical date agreed with the building owner representative on-site. Commissioning procedure shall conform to the “Mechanical Services” section of these specifications.
- The calibration and commissioning procedure shall consist of validating field I/O calibration, loop checks, actuator stroking and integrated system operation validation. All commissioning information shall be documented on commissioning data sheet forms which shall be submitted to the commissioning agent, if available, or the facility personnel for

approval prior to testing. Notify the facility personnel of the testing schedule so that operating personnel may observe calibration and commissioning.

4.13 TRAINING

The chilled water plant control system manufacturer shall instruct the personnel of the facility in the operation of the control system. Drawings, operation and maintenance manuals are to be provided to the customer in a single binder, clearly indexed.

4.14 MINIMUM REQUIREMENTS

i) Sequence of operation

- The CPM shall provide coordinating control for multiple chillers, cooling towers, pumps and valves as described herein. All logic for the control of these devices shall reside in the CPM application software.
- The application software in the CPM shall provide sequencing and staging of chillers, leaving chilled water temperature control, cooling tower control, condenser water pump control, scheduling and alarm processing for the CPM system and the chillers.
- The CPM shall enable and disable chillers, so that the current cooling capacity is matched to the current cooling load by controlling all running chillers to a common supply water temperature.

ii) Sequencing of chiller

Chillers shall be sequenced based on run-time; the chiller with the lowest number of run hours as the lead chiller, the chiller with the second lowest number of run hours as the second chiller, and so forth. Chiller must run at energy efficient mode.

iii) Staging of chillers

- The CPM shall calculate the load of all chillers running to determine when the number of enabled chillers should be increased or decreased. Each chiller shall communicate its current load status to the CPM.
- The CPM staging control shall ensure sufficient chillers are running to maintain correct cooling capacity and flow demand at all times.
- The CPM shall disable a chiller and stage-up so that another chiller is started when any operating chiller becomes unavailable due to chiller failure.

- The CPM shall decrease the system capacity by one stage when the chiller system load decreases by the capacity of the chiller that is the next to be switched off in the sequence.
- The stage down strategy must ensure correct cooling capacity is maintained to match current load whilst chillers shall be staged off as quickly as possible to save energy.

iv) Chiller load limiting

The CPM shall provide load limiting of each chiller through a Capacity Limit Set-point of 20-100%, which shall be sent to each applicable chiller. The value will be a common value sent to all chillers.

v) Chiller diagnostics

The CPM shall provide built in logic for chiller diagnostics. The diagnostics should include as a minimum.

- i) Evaporator delta T
- ii) Evaporator approach
- iii) Condenser delta T
- iv) Condenser approach
- v) Compressor suction superheat
- vi) Compressor Discharge superheat
- vii) Net oil pressure

The above values are monitored and compared to two envelopes of low and high limits.

Should a value drift out of the first envelop a warning is generated. Should the value drift out of the second envelope a fault is generated.

vi) Cooling tower

- This control strategy is designed to maintain the condenser entering temperature at a predefined set-point or wet bulb calculated set-point using VFD controlled cooling tower fans. The function calculates a variable frequency speed signal that is controlling the speed of all running cooling tower fans.

- As fan power reduces by the cube of the fan speed and fan and tower capacity reduces linearly, the most efficient mode of operation is to keep all fans operating at low speed as long as possible, this strategy also maximizes the use of all the available cooling tower heat exchanger surface.
- Minimum recommended fan speed is ~30%, this is because VFD drive efficiency falls away
- rapidly below 25% and excess vibration may be encountered. In addition, in a gear driven fan the gearbox (if applicable) usually has a minimum speed requirement of 30% in order to maintain lubrication capabilities.

vii) Recirculation Pumps

- Pumps shall be sequenced based on run-time; the pumps with the lowest number of run hours as the lead pump, the pump with the second lowest number of run hours as the second pump, and so forth.
- Chilled/ Condenser water pumps (Scope of Pump Logic Control System)
- The secondary pumps maintain a differential pressure at a specific point in the system. This point is the pressure difference across the most significant distant load. The pressure difference is the coil, piping, and control valve pressure drop at design flow. As the building cooling loads are satisfied, the coil two-way control valves move toward the closed position, this increases the differential pressure measured across the cooling coil, valve and piping.
- As the differential pressure starts to rise, the frequency converter slows
- The secondary pump to maintain the differential pressure setpoint value. The frequency converter
- setpoint value is the sum of the pressure drop of the cooling coil, coil piping, and PICV under design flow conditions.
- Pump Logic Control System (Diff. Pressure Sensor) is continuously monitoring the individual chiller flow. If particular chiller flow goes below the required chiller flow then PLCS will ramp up the VFD speed.
- When CPM/Scheduler gives start command to Chiller Plant, CPM will give first command to PLCS to start initially chilled water pumps. Once Chilled water flow established in chillers,

CPM will give command to Condenser Pump & Cooling Towers. Now Chiller will conform the condenser flow also & thus CPM will give command to Chiller.

- CPM will also give feedback of total running chillers to PLCS.

viii) I/O points

The following minimum number of I/O points should be included in CPM: REFER BOQ FOR MORE DETAILS

- i) For all Condenser pumps and fans: Command (DO), Trip (DI), Feedback (DI),
- ii) Manual/auto (DI)
- iii) Chilled Water Supply and return temperature (AI)
- iv) Condenser supply & return temperature (AI)
- v) Ambient temperature and humidity (AI)
- vi) Isolation valves: Command (DO), Status open (DI)
- vii) Chiller data points on Modbus

4.15 CPM description:

- A factory furnished, programmed, microprocessor-based controller shall be provided to supervise and optimize the operation of the individual Product Integrated Controllers (PIC) for each chiller. All application software actually performing the required control functions shall be factory supplied with the controller and shall be pre-tested and pre-configured.
- The networked chiller Product Integrated Controllers (PICs) shall interface with a CPM installed on the network. The CPM shall include software that allows dynamic interaction between the CPM and the chiller PIC(s) to create a complete chilled water plant system as described within this specification.
- The CPM shall include inherent input and output capability. The input/output capability shall include as a minimum a combination of standard HVAC sensor inputs (5k, 10k, 4- 20ma and discrete) an output to drive an alarm annunciator and/or alarm light, and two analog outputs for differential pressure control.
- Each analog input channel shall include an operator adjustable sensor trim (adjustable to 1/10oF) and programmable low and high alarm/alerts, as applicable.

The CPM shall not interfere with the PIC's stand-alone operating or safety algorithms but shall enhance the operation by providing the following inherent capabilities as a minimum:

- i) Control of up to eight chillers (staged or rotary) of equal or unequal sizes.
- ii) Enable/disable the chiller plant based on its internal time schedules, remote contact closure, analog temperature override, network command, or time schedule override.
- iii) Chiller fault logic and automatic starting of lag chiller(s).
- iv) Automatic alarming and switching to backup sensors if any primary sensor fails
- v) Diverse operator selectable chiller sequences including a sequence with a designated chiller to perform "feathering" functions.
- vi) Algorithms that properly match the chillers with the load.
- vii) Chiller inhibit timers
- viii) Bypass valve control
- ix) KW balancing and Ramp loading
- x) Demand limiting
- xi) Chilled water reset
- xii) Power fail restart

The CPM shall contain factory programmed software for the following types of mechanical systems:

- 1. Two to eight chillers with dedicated chilled water pumps and no secondary piping.
- 2. Two to eight chillers with chilled water pumps in a parallel arrangement and no secondary piping.
- 3. Two chillers piped in series with a single chilled water pump and no secondary piping.
- 4. Two to eight chillers with dedicated primary (production loop) pumps and secondary (distribution loop) pumps piped in a parallel arrangement.
- 5. Two to eight parallel chillers, common primary pumps, constant flow (common constant speed secondary pumps), variable flow (two-way valves) with a differential pressure valve and bypass line.
- 6. Two to eight parallel chillers, common primary pumps, variable flow (two-way valves), with a differential pressure valve and bypass line.

4.16 CPM Attributes

- The controller shall be powered from standard, off the shelf, Class II, 24 volt transformers. The controller shall be listed under UL916-PAZX (Energy Management), UL 864-UDTZ (General Utility Signaling), VDE, and CSA. Products shall be manufactured in a facility having a Quality System that is registered to either ISO 9002 or ISO 9001 Quality Assurance Standard. The controller shall be designed to be easily mounted in a standard NEMA 1 type enclosure without special rails or mounting hardware and as local and national code dictates.
- The controller shall include a 365 day real time clock and watchdog timer diagnostic indicator provided by a LED. The watchdog timer shall reset upon power on and be resettable by software thereafter. Should the watchdog timer not be resettable during the timing period, it shall time out and set all outputs to their non-powered state. The LED shall illuminate solidly to indicate this failure.
- The controller shall not require a battery. All configuration data will be stored in non-volatile memory. The controller shall provide a minimum of two days data retention for the time clock. Systems that require a battery to store data are not acceptable.
- The controller shall include the capability to provide a local interface for all operating values, alarms, etc., via a panel mounted, Local Interface Device. The controller shall also be capable of interfacing to a portable PC for configuring or altering the configuration, setting the address, performing uploads/downloads, etc. through a separate, additional RJ14 plug.

4.17 GENERAL

A Chiller Plant Manager (CPM) system will be included with the chillers (where specified) to provide coordinated chiller plant operation, optimize energy efficiency, equipment protection with alarms, and all other requirements of a central chilled water plant. The CPM will also serve as an essential chiller management tool for owner personnel. This specification details specific features and functional requirements of the CPM System. In addition and priced separately, the CPM System shall be capable of controlling all central plant equipment, if so specified.

4.18 ACCEPTABLE SUPPLIERS

The Chiller Plant Automation (CPM) system shall be furnished by the chiller manufacturer only.

4.19 SUPPLIER RESPONSIBILITIES

The chiller manufacturer will be responsible for CPM System hardware, sensors, installation, programming, wiring, start-up, submittal, project documentation, warranty, and all other provisions of this specification. The chiller manufacturer will comply with the provisions of this specification as a requirement to be an acceptable supplier of the chillers and the CPM System.

4.20 BID SUBMITTAL

The following Bid Submittals are required for an acceptable proposal of the CPM System:

- 1 CPM Equipment Dimensions
- 2 Chiller Plant Sequence of Operation
- 3 CPM software description and operation
- 4 CPM Equipment Data Sheets
- 5 Monitoring and Control Points List (indication of equipment to be installed by others)
- 6 RS-232C Compatibility Specification and Instructions
- 7 Installation List, with at least 30 installed systems
- 8 Exceptions and deviations from specification

4.21 CPM HARDWARE

- The CPM System must be a microprocessor based programmable controller with the capability of specific chiller plant control, chiller interface, and operator use. The CPM will be designed to operate in a NEMA-1 standard equipment room environment and must be U.L. approved.
- Inputs - The CPM will have inputs for accepting signals from temperature sensors, pressures sensors, flow meters, chiller power use, equipment status, etc. The CPM must be capable of using analog inputs 0 to 10 volts DC, 4 to 20mA, digital switch closure, and pulse width signals. The chiller manufacturer will be responsible for selecting the appropriate method of system inputs and monitoring. Input quantity shall all be a minimum of four (4) inputs on up to 48 inputs according to the controller specified.
- Outputs - The CPM will control the chiller plant using Direct Digital Control (DDC). The CPM outputs must be capable of modulating/positioning valves, chiller control vanes, pump

speed, fan speed, and other devices. The CPM must be capable of both analog control 0 to 10 volts, digital switch closure rating of 24VAC, and pulse width modulation. The chiller manufacturer will be responsible for selecting the appropriate method of control. Output quantity to be minimum of nine (9) and a maximum of twenty-four (24) in a specified controller.

- HOA – Hand/Off/Auto Switch - All CPM outputs must have Hand-Off-Auto (HOA) switch for manual override of the system and indicating light(s) for output status.
- Communication Data Port - The CPM must have an RS-232 data port for communication to a printer, terminal, or PC. The data port must use standard industry ASCII communication protocol, selectable 300 to 9600 baud synchronous communication speed. RS-485 must be used for the LAN (Local Area Network) communication port.
- Communications to Other Building Automation Systems - The CPM will have a translator capability included that will transfer all inputs, alarm conditions, safety/cycling information to the BMS. The translator shall broadcast in 0 to 10VDC signals. These signals are to be generic and not require special protocols.
- The supplier of the BMS shall be responsible for the connections to the CPM Translator. Any special signal conditions needed by the BMS supplier are to be provided in their portion of these specifications.
- The translator shall be capable of receiving commands from the BMS to request information on each device controlled by the CPM and to change setpoints, alarm points, on-status of the chillers, maximum demand of each chiller, and parameters as recommended by the chiller manufacturer. In no case shall the translator accept an improper command that will make the chillers operate at poor efficiencies or be subject to possible damage.
- RS-232 Translator - The CPM will have an RS-232 Translator for equipment control interface to third party BMS via RS-232 ASCII protocol communication.
- Communications to remote Service/Control Stations - The CPM will have the ability to communicate via a modem to a remote station. The remote station shall not require a terminal or computer to receive information. However, such terminals shall also be capable of being used if desired by the owner and included in this specification.

4.22 OPERATOR DISPLAY AND INTERFACE

- The CPM must have a display panel for human interface, on-site access to chiller plant operating data, enunciation of system alarms and messages, and changes in chiller plant control. The operator display shall be built-in. The CPM System must have the following features:
- Keypad - Must have twenty (20) keys allowing access to all functions of the system; access of all chiller system temperatures, pressures, flows, calculated values, and equipment status. Also, change of chiller set point, chiller lead/lag selection, pull-down demand limit, chiller plant operating schedule, and other parameters as recommended by the chiller manufacturer for optimize chiller plant operation.
- Display - The CPM System display shall be a built-in display with a two line digital display of forty (40) characters per line and must be capable of displaying system temperatures, pressures, flows, calculated values, equipment status, valve position, system alarms, and messages.
- Other Features - The CPM System must have an audible means to enunciate system alarms by use of a beeper or horn in conjunction with the flashing alarm indication on the display screen.

4.23 SENSORS AND INTERFACE DEVICES

- The chiller manufacturer shall provide all sensors and interface devices for the CPM System. All sensors and devices shall be of the highest quality and reliability while meeting the following accuracy and specifications for proper chiller plant operation.
- Temperature Sensors - Temperature sensors shall be platinum or nickel RTD or thermistor also must be mounted in a separable well. Temperature sensor accuracy must be less than 1% over application range and at least $\pm 1/4^{\circ}\text{F}$ accuracy. Differential temperature sensors for chilled water temperature and load calculations must be 1°F accuracy.
- Other Sensors and Devices - Water pressure sensors, chiller kW/amp sensors, and refrigerant pressure sensors shall be 1% accuracy over the application range. All sensor mounts and fittings will be supplied by the chiller manufacturer and installed in the factory. System input sensors that are mounted in the field shall have piping installed by others. Water valves and operators will be supplied by others unless otherwise noted which then will be electric or pneumatic and interfaced with the CPM System. The chiller manufacturer

will approve valve operator vendors per specification. The mechanical contractor will install all valves in the piping as shown on drawings.

- Auxiliary Panels - The chiller manufacturer will provide any auxiliary panels for interface devices, where needed.
- Chiller Control Panel Compatibility - The CPM System and interface devices shall tie into the chiller control panel without override to its operating control and safety integrity and shall be installed by the chiller manufacturer unless otherwise noted. In the event of CPM panel failure, the microprocessor on the chiller unit shall provide English read-out and shall be completely capable of controlling itself at the last command setpoint issued by the CPM System.

4.24 CPM SOFTWARE

- The CPM System must have operating system software with specific features, capabilities for proper chiller plant control and future customer requirements. The CPM software will be preprogrammed with provisions for customer programmability plus custom control features to match all requirements. Canned programs without total flexibility for customer needs are not acceptable.
- Control Algorithms - The CPM must be capable of P, PI, and PID (Proportional-Integral-Derivative) control for chilled water temperature control, and condenser by-pass valve control, cooling tower fan control, chiller loading/unloading control, pump control, and other control algorithms. Setpoint, offsets, and rate factors must be adjustable for fine-tuning and chiller plant control stability.
- Decision Logic - The CPM must be able to make logic control decisions for intelligent chiller plant control decisions based on various operating conditions. The software must be able to perform comparisons, if then, greater than, less than, equal to, and similar logic decisions.
- Equation Processor - The CPM software must incorporate a means to do mathematical equations for calculating chiller plant variables and chiller operator information. Totalizing the data is also an essential requirement.
- Clock/Calendar - The CPM software and control algorithms must incorporate an uninterruptable real time clock capable of time of day, month, year, and day of week.

- English Commands and Messages - The CPM software must use English commands for system programming and operator commands. The software must also be capable of displaying/printing messages, alarms based on chiller plant operating conditions, and operator input in English.
- Security Access - The CPM software must have at least three (3) levels of password security to allow access to information only, limited chiller plant control changes, and CPM reprogramming respectively.
- Historical Data - The CPM software must be capable of accumulating historical data and equipment logs. The CPM must have sufficient memory to store at least 48 hours of chiller logs and weekly chiller plant management reports.
- Other Software Features - The CPM must be capable of interfacing to a smart modem, be capable of auto-answer, and auto-dial for remote access, and shall have voice communication capabilities on-board the unit.
- Graphing - The CPM must be capable of graphing the relationship of 3 inputs. This capability must be provided and demonstrated at start-up and at acceptance of the system.
- Translation of Information - The CPM must be capable of including the software necessary to perform the functions of the translator described in this specification.

4.25 SEQUENCE OF OPERATION

- The CPM System will be programmed for specific sequences of operation to provide chiller plant operating efficiency by the use of automatic equipment operation, equipment protection, translation of data, and alarms. The chiller manufacturer will provide appropriate control application for customer chilled water plant and must include the following:
- Adaptive Start/Stop - The CPM will minimize equipment energy use and automatically adjust chiller-pump-tower start/stop schedule(s) by zone space temperature, chilled water temperature, and historical cooling load inertia/reaction time. Chilled water pumps, condenser pumps, tower, and chillers will be controlled separately for optimum start time and stop time. The CPM will determine if water temperature can be reduced from a level reached during idle times before starting chiller compressor. The CPM will determine if water temperature is suitable for shutdown of chiller compressor in advance of actual un

occupancy time. In no case will a single contactor be allowed to shut everything down simultaneously.

- Chiller Sequencing/Selection - Lead/Lag chiller selection will be determined and can be rearranged upon customer selection. The CPM will automatically forecast cooling load requirement/trend and automatically select optimum equipment combination based on historical energy efficiency, load requirements, chiller-pump-tower kW, and chiller-ready-to-run. The customer may alternatively select optimize/equal chiller run time. Chilled water and condenser water valve(s) will be opened/closed based on chiller selection. The CPM shall be capable of controlling any chiller configuration. Owner shall be able to start chillers at one location or shall be able to select automatic start. Any chiller commanded to start but not doing so will be a designated alarm. Operator will be alerted to start the next most optimum chiller by chiller number location.
- Optimum Chiller Load Distribution - CPM will automatically load individual chillers based on energy efficiency and optimum equipment combination. The CPM will also reset leaving chilled water temperatures on individual chiller(s) to optimize chiller load distribution while maintaining chilled water supply/return set point mode. Any parallel chiller that is in circulation but does not have water circulating, the evaporator will be in alarm.
- Chilled Water Reset/Condenser Water Reset - The chiller(s) leaving chilled water will be automatically reset/adjusted based on one of the following (customer selectable) methods: (1) constant chilled water supply temperature for individual chiller or common supply; (2) constant return water temperature control; and, (3) chilled water reset based on outdoor temperature or outdoor humidity. Minimum and maximum reset limits are customer defined. The condenser water supplied to the chiller shall be lowered as much as to the leaving temperature to reduce lift and provide maximum savings.
- Low Load Control - An individual chiller will not be allowed to operate below a selectable operating point (i.e. 30% load) unless only one chiller is required for the cooling load. For cooling load below 25%, the CPM will select to cycle the chiller to maximize energy efficiency or select continuous operation based on cooling load inertia/reaction time and historical data.

- Auto Start after Power Failure - In the event of a power failure, all equipment will remain off for a select period. Equipment will then be sequentially started to minimize kW peak demand.
- Auto Start of Standby Chiller - If a chiller or its auxiliary equipment fails to start or shuts down on safety failure, a standby chiller and its associated auxiliaries will be started.
- Failure Alarms - The CPM shall recognize and enunciate chiller, pump, and fan failure by means of positive proof feedback and/or safety failure circuit. An alarm message will be displayed and beeper/horn sounded.
- Pull-Down Demand Limiting - Upon start-up, the chiller is gradually loaded to a selectable kW limit for a selectable period of time prior to allowing full loading.
- Cooling Tower Control (where applicable) - Cooling tower by-pass valve is modulated to maintain minimum condenser water supply temperature. This temperature is adjusted in accordance with outside conditions. Cooling tower fans are automatically cycled based on chiller operation. For optimize energy efficiency, cooling tower fan ON/OFF and fan speed is automatically selected based on fan kW rating and incremental chiller kW change.
- Pump Sequencing and Control - Pumps are started prior to chiller start-up and are sequenced based on chiller operation and cooling load requirement. Pump shut-down is based on same. Pump speed is controlled by pump pressure on secondary pumps equipped with variable speed control.
- Total Chiller Plant Optimization - The CPM sums cooling tower fan's kW, pump's kW, chiller's kW, and automatically selects and operates equipment for maximum energy efficiency based on load forecast, historical efficiency, and optimum equipment combination.
- Free Cooling Control - The CPM automatically selects free cooling mode based on the condenser by-pass valve position leaving tower water temperature 2°F below chilled water supply temperature and outdoor temperature trend. In the free cooling mode and load sharing mode, the condensing cooling water pump is on, water control valves are modulated to maintain chilled water set point, and cooling tower fans are selected (OFF/ON) based on incremental free cooling (tons) per tower fan kW. Free cooling and load sharing mode is deactivated (OFF) upon 1°F below chilled water supply temperature.

4.26 ALARMS AND MESSAGES

The CPM System must be capable of displaying chiller plant alarms and messages. Minimum requirements include chiller failure alarms, pump failure alarms, tower fan failure alarms, high/low temperature alarms, high/low alarms for all inputs, high/low alarms for all calculated variables (i.e. chiller efficiency), and CPM System diagnostics.

4.27 REPORTS AND CHILLER LOGS

The system must be capable of accumulating and displaying chiller plant data, historical chiller logs, and reports. Minimum report requirements include chiller historical kWh use, heating/cooling degree-days, chiller run times, lead/lag selection, historical cooling load, BTUH/Ton-hrs, number of chiller failures, most recent chiller alarm, cooling tower run times, pump run times, free cooling run times, and total chiller plant (est.) power use. Minimum chiller log requirements include all chiller plant operating temperatures, pressures, chiller kW, pump, tower and chiller operating status, and total system (est.) energy use. All logs must be available for a previous 48 hours, in 2-hour increments.

4.28 BMS COMPATIBILITY

The CPM must be capable of interface with a third party Building Management System (BMS) through Translator or communication link. The chiller manufacturer will provide interface instructions prior to bid so that all work by others can be identified.

4.29 PC COMPATIBILITY

The CPM must be capable of ASCII communication to a PC through an RS-232 direct connection or telephone line. The chiller supplier must submit interface instructions and a list of PC software (proprietary or third party) capable of interface of chiller, communication, display of chiller data, reports, and alarms.

4.30 WIRING AND PNEUMATICS

Wiring - The HVAC Vendor shall provide all labor, material, and install all control wiring for all sensors, control devices, equipment interfaces, and electrical power to the CPM System. All wiring will be in accord with local and national Electrical Codes which also must be properly labeled. All wiring must be installed in EMT conduit.

4.31 PROJECT DRAWING AND DOCUMENTATION

Project drawings must be submitted after installation and completion of the CPM System. The chiller manufacturer will provide three (3) copies of the following:

- As-built wiring diagrams
- Installed Bill of Material
- Sequence of Operation
- CPM System Operation's Manual

4.32 CUSTOMER TRAINING

The chiller manufacturer will provide one (1) day of on-site operator instruction to designated customer personnel. Training will include routine operation, use of optimize chiller plant operation, controller maintenance, and use of chiller energy management features. The CPM supplier must also offer, at the Owner's expense, a three (3) day factory training course.

4.33 SYSTEM WARRANTY

After project completion, the chiller manufacturer will provide 24 months (or as specified under GENERAL CONDITIONS OF CONTRACT) of CPM service with total responsibility for warranty including hardware, sensors, wiring, labor, and software. The chiller manufacturer will provide a minimum of four (4) routine inspections by a qualified Service Technician who will inspect, adjust, and verify proper CPM System operation. The chiller manufacturer will provide software support, including a back-up copy of software programming and will provide minor software changes as deemed necessary by the chiller manufacturer to assure proper system operation.

4.34 SYSTEM FUTURE

The CPM System shall be expandable into a Building Management System. Although not a requirement of this section of the specification, supplier must demonstrate that the system is fully expandable from the central plant up to a building wide system using standard components manufactured by the chiller supplier. The components are to be fully distributive and totally stand-alone modules as previously described.

5. COOLING TOWER**5.1 SCOPE**

The scope of this section comprises the supply, erection, testing and commissioning of cooling towers in accordance with requirements of Drawings and of the Bill of Quantities. The tower selection shall be **CTI Approved** based on the monsoon wet bulb temperature specified in the Design brief report.

5.2 TYPE & CAPACITY

Cooling Towers type and capacity shall be in accordance with requirement of Drawings and Bill of Quantities.

Single-Cell Induced draft counter flow type	
Temperature of condenser water entering Cooling Tower	96.9 ° F
Temperature of condenser water leaving Cooling Tower	86.6 ° F
Wet Bulb Temperature	81.8 ° F
Max. Water Flow Rate (US gpm / TR)	≈ 3.0
Number of Cells	1
Range, ° F	10 ° F
Approach,	5 ° F
Max. Percentage Losses (including bleed off) / Makeup water requirement of Re-circulating cooling water, %	1.2

5.3 COMPONENTS OF COOLING TOWER

The basic components of cooling tower are: Frame and casing, twin cell, fill, cold water basin, drift eliminators, air inlet, louvers, nozzles and multiple fans.

5.4 FRAME AND CASING

Cooling towers shall have structural frames that support the exterior enclosures (casings), motors, fans, and other components. The cooling tower shall have at least twin-cell construction. This shall be made out of FRP construction with smooth surface on both sides for minimum resistance to air flow. It shall have sufficient structural strength to adequately withstand high wind velocities and vibration. The casing may be installed in the reinforced cement concrete basin if so identified in drawings, or in Bill of Quantities. The tower supporting structure shall be made out of hot dipped galvanized tubular frame. Air intake shall be all along the sides so that tower can be installed quite independent of prevailing wind direction. Anodized aluminium or PVC louvers integrated with fill and backed up by galvanized bird screen shall be provided at air intake. Sufficient clearance between casing and adjoining structures shall be provided to enable servicing and periodic cleaning. The fan guard shall be designed to prevent contact between fan and human finger.

The tower structure and the components shall be designed to withstand a wind and seismic load as per standard codal provisions.

5.5 FILL:

Fillings shall be made of corrosion proof and rigid PVC film in honeycomb design and arranged in square / rectangular form to facilitate heat transfer by maximizing water and air contact. Fill sheets shall be suspended from H.D.G steel structural tubing supported from the lower structure & shall be elevated above the floor of the cold-water basin to facilitate cleaning and easy replacement. They shall be arranged in such a manner to ensure negligible resistance to air flow and to eliminate back water spots and prevent fouling through scales that may form. In order to reduce carry-over losses through entrainment of moisture drops in air stream, PVC drift eliminator shall be installed.

5.6 COLD WATER BASIN:

- The cold-water basin shall be located at or near the bottom of the tower, to receive the cooled water that flows down through the tower and fill. The basin usually has a sump or low point for the cold-water discharge connection. Cold water basin shall be made of FRP by others. The basin shall be accessible and maintainable while circulating the water. Brass float operated make-up valve and side outlet sump complete with replaceable stainless steel section screen and anti-cavitations device shall be provided.
- Basin fittings shall include the following:

- Bottom outlet & Screened suction assembly.
- Drain connected to the side / underside of basin.
- Quick fill & Overflow connected to the side of basin.
- Built-in bleed off attached to inlet header discharging through polyethylene tube into overflow pipe.
- Ball type automatic make up water valve.
- Float Valve
- Equalizing connection and balancing valve for multiple CTs.

5.7 DRIFT ELIMINATORS

Drift eliminators capture water droplets entrapped in the air stream that otherwise would be lost to the atmosphere. Drift eliminators shall be efficient enough to effectively limit drift loss to no more than 0.005% of the designed flow rate.

5.8 AIR INLET

This is the point of entry for the air entering a tower. The inlet may take up an entire side of a tower for cross flow design or be located low on the side or the bottom for counter flow designs.

5.9 LOUVERS

The purpose of louvers is to equalize air flow into the fill and retain the water within the tower. The cross-flow towers have inlet louvers and counter flow tower designs do not require louvers.

5.10 NOZZLES

These provide the water sprays to wet the fill. Uniform water distribution at the top of the fill is essential to achieve proper wetting of the entire fill surface. Nozzles can either be fixed in place and have either round or square spray patterns or can be part of a rotating assembly as found in some circular cross-section towers.

5.11 FAN & MOTOR

- The fan shall be axial-flow type, gear driven, multi aerofoil blades with variable pitch. The fan blades shall be made of aluminum alloy and housed within a fan cylinder, design for smooth unobstructed air entry. The fan shall be factory balanced both statically and dynamically. A fan having non-automatic adjustable pitch blades permits the same fan to be used over a wide range of kW with the fan adjusted to deliver the desired air flow at the lowest power consumption. Automatic variable pitch blades can vary air flow in response to changing load conditions. Direct driven fan speed shall not exceed 700 RPM.
- The fan motor shall be totally enclosed fan-cooled, weatherproof type. It shall be connected through a set of easily adjustable and low maintenance.
- Fan shall be driven by $415 \pm 10\%$ volts, 3 phase, 50 cycles, AC supply, energy efficient motor, totally enclosed air over (TEAO), fan-cooled, weather-proof construction (IP55), Class F, designed and selected to operate in humid air stream. Fan shall be protected by a fan guard and bird screen of galvanized steel construction to prevent birds from nesting during idling period & shall be easily accessible for inspection and maintenance. G.S.S canopy shall be provided over the fan motor for protection against rainwater. Motor terminal box shall be made watertight.
- The cooling tower fan motor shall be suitable for operating with Variable Frequency Drive as specified in the BOQ.

5.12 HANDRAIL & LADDER

Hot Dipped Galvanized made Ladder & Handrail should to access to the top of the cooling tower should also be part of scope.

5.13 CONTROL SYSTEMS

It should be possible to hook up to BMS. All necessary hardware & software should be part of the scope.

5.14 VIBRATION ISOLATORS

Vibration Isolators of spring open type designed to minimize any vibration from transmitting to other structures to be included in the scope of supply.

5.15 LOW NOISE TYPE

Cooling tower supplied should be of low noise type & noise level at 1.5mtr distance from the tower should not be more than 75 dBA. Please attach computer selection noise transmission data for obtaining approval from acoustic consultants.

5.16 DISTRIBUTION SYSTEM

Hot water distribution system shall comprise of header and branch arms system with flow balancing system or open pan gravity flow system. No overflow or splash of water shall be allowed at design flow rates.

5.17 SUBMITTALS

Provide the following in addition to the standard requirements with the Bid:

- Structural steel support including dimensions, sizes, and locations for mounting bolt holes, include weight distribution drawings showing point loadings.
- Total fan BHP (driver output)
- Drift loss (percent of circulating flow)
- Evaporation loss (at design)
- Tower cells (to be provided).
- Thermostat and heater wiring drawings and catalog cut information.
- Control / Operational Logic for CT Fan's VFD
- The cooling tower submittal shall include performance curves in accordance with Section 11 of ATC-105. A manufacturer's guarantee, performance bond, or test by the manufacturer will not be accepted as an alternative to CTI certification or an independent field test.

5.18 PERFORMANCE DATA

Complete performance ratings and power consumption at varying loads and outdoor wet bulb temperatures, shall be submitted and verified at the time of testing and commissioning of the installation.

5.19 TESTING

Capacity of the cooling tower shall be computed from the measurements of water flow, incoming/outgoing water temperatures and ambient air wet bulb temperature using accurately calibrated mercury-in-glass thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption for cooling towers shall be computed from measurements of incoming voltage and input current.

6. PRIMARY, SECONDARY AND CONDENSER PUMPS**5.1 SCOPE**

The scope of this section comprises the supply, erection, testing and commissioning of water pumps conforming to these Specifications and in accordance with requirements of Bill of Quantities.

5.2 CAPACITY

Capacity of pumps for air conditioning applications shall be in accordance with requirement of Drawings and Bill of Quantities. The pump and motor shall be of weatherproof construction.

5.3 CASING

Pump Casing - Cast Iron for working pressure to 12bar at 65°C (PN16 flange rating) and Ductile Iron for working pressures to 25bar at 65°C (PN25 flange rating). Suction and discharge connections shall be flanged and the same size and shall be drilled and tapped for seal flush and gauge connections.

5.4 IMPELLERS

Impeller shall be bronze, enclosed type, hydraulically balanced and passages smooth-finished for minimum friction and maximum efficiency. The impeller shall be secured to the shaft by feather and nut.

5.5 WEARING RINGS

Wearing rings are provided for pump 12" & above to maintain close running clearance and to minimize pressure leakage between suction and discharge chambers of the casing. The casing bearing rings shall protect the casing against wear and shall be locked in pump casing to prevent rotation.

5.6 SHAFT

Shaft shall be steel Stainless-Steel SS-304. Pumps shall be fitted with outside balanced mechanical seals (factory fitted). The shaft shall be of high strength steel with optimum diameter to provide maximum strength with minimum shaft deflection.

5.7 COUPLING:

Rigid spacer type of high tensile aluminium alloy. Couplings shall be split to allow removal from pump and motor shafts, leaving space between the shafts sufficient to replace all mechanical seal components without disturbing the pump or motor.

5.8 MECHANICAL SEAL

Seal shall be Stainless Steel outside multi-spring balanced type with carbon Vs silicone carbide faces and Viton secondary seal. Provide stainless steel gland plate with Stainless Steel trim. Provide factory installed flush line with manual vent. All split coupled pumps shall be provided with a lower seal chamber throttle bushing. Seal flush line fittings, if required: Supply in the flush line to the mechanical seal a 50 micron cartridge filter and sight flow indicator, to suit the working pressure encountered. Filters shall be changed, by the installing contractor, after system is flushed and on a regular basis until turned over to the owner. Alternately, for pumps with differential pressures exceeding 200 kPa Supply in the flush line to the mechanical seal a cyclone type separator, with sight flow indicator.

5.9 DRIVE MOTOR

Motor shall be energy efficient, totally enclosed, fan-cooled, Class-F insulation. Motor shall be specially designed for quiet operation and its speed shall not exceed 1440 rpm. The motor rating shall be such as to ensure non overloading of the motor throughout its capacity range. Motor shall be suitable for $415 \pm 10\%$ volts, 3 phases, 50 cycles AC, power supply. The motor type shall be EFF-1. The motor shall be suitable for VFD operation. The motor and pump shall be designed suitable for operating at 115% of design capacity.

5.10 ALIGNMENT

The pump and motor shall be aligned by the pump manufacturer. The pump manufacturer shall provide certification to the effect that the pump and motor coupling has been carried out by them and checked by them. No need for realignment after installation.

5.11 PAINTING

All pumps, motors and bases shall be supplied with approved finish. Shop coat of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the adjoining areas.

5.12 INSTALLATION

The pump shall be capable of getting installed with pipe support and without flexible connectors on the suction and delivery side.

5.13 REGULATORY REQUIREMENTS

- Conform to Health/Life Safety Code Conform to International Mechanical Code
- Conform to BOCA National Building Code
- Conform to State of Illinois Plumbing Code
- Conform to National Electric Code NFPA 70
- Conform to applicable ANSI/HI standards
- Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

5.14 DELIVERY, STORAGE & HANDLING

- Deliver materials to the site in such a manner as to protect the materials from shipping and handling damage. Provide materials on factory provided shipping skids and lifting lugs if required for handling. Materials damaged by the elements should be packaged in such a manner that they could withstand short-term exposure to the elements during transportation.
- Store materials in clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage.

5.15 PERFORMANCE TESTS

The Contractor shall after installation carry out commissioning tests and ensure that the specified flow rate and head are achieved, by means of Direct Reading Flow meter.

The following tests shall be conducted at the rated RPM of the pump in the presence of **Client / Architect / Consultant's** representative for performance as per relevant IS Standards.

- Discharge Vs Head
- Discharge Vs Efficiency

- Discharge Vs BHP
- Hydraulic tests for casing at 1.5 times of the design pressure

Performance test shall be conducted at the following operating points.

- Shut Off
- Rated duty point
- 120% rated capacity.

The Contractor shall submit detailed performance curves for the pumps supplied along with the tender.

The pump head given in the BOQ / drawing is minimum required for the system. Actual head shall be calculated and confirmed by the vendor at the time of bidding. The pump head calculation based on the approved shop drawing shall be submitted by the vendor and upgrade the pump & motor to the requirement, without any extra cost to the Client.

5.16 COMPONENTS OF VARIABLE SPEED PUMPING SYSTEM

Pump Logic Controller (should be fully compatible to hook up to Chiller Plant Manager / BAS)

- The technologic pump logic controller factory assembled with UL listed components
- The Equipment should be able to hook up to chiller plant management system (BMS) via software integration either in BacNet / RTU Modbus Protocol. Necessary hardware / software for integration should be part of scope.
- The controller shall be specifically designed for variable speed pumping applications.
- The controller shall function to proven program that safeguards against damaging hydraulic conditions including:
 - i) Pump flow surges
 - ii) Hunting

iii) End of curve

iv) System over pressure

- The pump logic controller shall be capable of receiving up to two discrete analog inputs from zone sensor / transmitter as indicated on the plans. It will then select the analogue signal that has deviated the greatest amount from its set point. This selected signal will be used as the command feedback input for a hydraulic stabilization function to minimize hunting. Each input signal shall be capable of maintaining a different set point value. Controller shall be capable of controlling up to three pumps in parallel.
- The pump logic controller shall be capable of accepting an additional analog input for a flow sensor. This input shall serve as the criteria for the end of curve protection algorithm.
- The pump logic controller shall be self-prompting. All messages shall be displayed in plain English. The operator interface shall have the following features:

v) Multi-fault memory and recall last 10 faults and related operational data.

vi) Red fault light, yellow warning light and Green power on light.

vii) Soft-touch membrane keypad switches.

- The display shall have four lines, with 20 characters on three lines and eight large characters on one line. Actual pump information shall be displayed indicating pump status.
- Controller shall be capable of performing the following pressure booster functions:

viii) Low suction pressure cutout to protect the pumps against operating with insufficient suction pressure.

ix) High system pressure cutout to protect the piping system against high-pressure conditions.

x) No flow shutdown to turn the pumps off automatically when system demand is low enough to be supplied by hydro pneumatic tank. No flow shutdown shall require any external flow meters, flow switches, nor does pressure switch to determine when a No Flow conditions exist.

- The following communication features shall be provided to BAS:

xi) Remote system start / stop non-powered digital input.

xii) Failure of any system component. Output closes to indicate alarm condition.

xiii) Four 4-20 mA output with output of

- Frequency

- Process variable
- Output current
- Output Power
- The following communication features shall be provided to the Chiller Plant Management System (Building Automation system) via an RS-485 port suitable to hookup either in BacNet / RTU Modbus protocol. Necessary hardware / software required for integration should be part of scope.

- xiv) Individual Analog Input.
- xv) Individual Zone Set points.
- xvi) Individual Pump / VFD on/off status
- xvii) System percent speed
- xviii) System start/stop command
- xix) System operation mode
- xx) Individual kW signals
- xxi) System flow, when optional flow sensor is provided.

- The pump logic controller shall be of a high end type i.e. all the parameters available on the logic control panel should be able to monitor / controlled from the remote location and should be housed in a NEMA 1 Enclosure.

5.17 SENSOR / TRANSMITTERS

Provide field mounted differential pressure sensor transmitters as indicated in the BOQ & also in the drawings. Unit shall transmit an isolated 4-20 mA dc signal indicative of process variable to the pump logic controller via standard two wire 24 DC system. Unit shall have a corrosion resistant steel body with 1/8" NPT process connection. It shall have a NEMA 1 electrical enclosure capable of withstanding 450-PSI static pressure. Accuracy shall be within 0.5% of full span.

5.18 SEQUENCE OF OPERATION

- The system shall consist of Technologic pump logic controller, multiple pump / VFD sets, with manual and automatic alternation and pump staging.

- The pumping system shall start upon the closure of customer's contact when pump logic controller mode of operation selector switch is in the REMOTE position.
- When the pump logic controller selector switch is in the LOCAL position, and start command on controller is given via operator interface, the pumping system shall operate automatically.
- Sensor / transmitter shall send a 4-20 mA signal to the pump logic controller, indicative of process variable condition.
- The pump logic controller shall compare each signal to the independent engineer / user determined set points.
- When all set points are satisfied by the process variable, the pump speed shall remain constant at the optimum energy consumption level.
- The pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the latest satisfied zone.
- If the set point cannot be satisfied by the designated lead pump, the pump logic controller shall initiate a timed sequence of operation to stage a lag pump.
- The lag pump shall accelerate resulting in the lead pumps decelerating until they equalize in speed.
- Further change in process variable shall cause the pumps to change speed together.
- When the set point criteria can be safely satisfied with fewer pumps, the technologic pump logic controller shall initiate a timed sequence and continue variable speed operation
- As the worst-case zone deviates from set point, the pump logic controller shall send the appropriate analog signal to the VFD to speed up or slow down the pump/motor.
- In the event of a VFD fault, the pump logic controller automatically initiates a times sequence of events to start the redundant pump/VFD set in the variable speed mode. The redundant variable speed system shall be started through the pump logic controller.
- Upon VFD faults, the pump controller shall display an alarm condition through a plain English message.

- VFD fault indication shall be continuously displayed on the operator interface of the pump until the fault has been corrected and the controller has been manually reset.
- In the event of the failure of a zone sensor/transmitter, its process variable signal shall be removed from the scan/compare program. Alternative zone sensor/transmitters, if available, shall remain in the scan/compare program for control.
- Upon sensor failure a plain English warning message shall be displayed on the operator interface of the pump logic controller.
- In the event of failure to receive all zone process variable signals, a user selectable number of VFDs shall maintain a user adjustable speed; reset shall be automatic upon correction of the zone failure.

5.19 Technical Requirements for Water cooled chiller:

SL.No.	Description	Primary Water Pumpsets serving Water Cooled Chillers	Secondary Pumpsets serving Water Cooled Chillers	Condenser Water Pumpsets serving Water Cooled Chillers
A	Design Features			
1	Pump designation	Vertical Inline & Constant Speed	Vertical Inline & Variable Speed	Vertical Inline & Constant Speed
2	Minimum Design Capacity	As per BOQ.	As per BOQ.	As per BOQ.
3	Head	12 Mtr	30 Mtr	25 Mtr
4	Location	Outdoor / Indoor	Outdoor / Indoor	Outdoor / Indoor
5	Maximum rated speed	1140 GPM	1140 GPM	1425 GPM
	at 50 Hz	(3W + 1S)	(3W + 1S)	(3W + 1S)
6	Liquid Handled	Water	Water	Water
7	Quantity Required	As per BOQ.	As per BOQ.	As per BOQ.
8	Efficiency	85%	85%	85%
9	Power Consumption	22 W/gpm	22 W/gpm	19 W/gpm

B	Features of Construction			
1	Type of Pump	As mentioned in BOQ	As mentioned in BOQ	As mentioned in BOQ
2	Impeller	Enclosed	Enclosed	Enclosed
3	Shaft	Coupled	Coupled	Coupled
4	Drive Transmission	Direct	Direct	Direct
5	Seal	Mechanical Seal	Mechanical Seal	Mechanical Seal
6	Prime Mover	AC Electric Motor IE 4	AC Electric Motor IE 4	AC Electric Motor IE 4
7	Variable Frequency Drive	Not Required	Required	Not Required
8	Logic Control Panel	Not Applicable	Required. Should be able to transfer the entire signal available on the display panel to BMS. Necessary hardware & software for integration should be part of the scope. Signal should be in ASHRAE Bacnet / RTU Modbus Protocol	Not Applicable
9	Differential Pressure Sensor / Transmitter with Control Cabling	Not Applicable	Should be considered as mentioned in BOQ.	Not Applicable

C	Material of Construction			
1	Impeller	Bronze / Stainless Steel	Bronze / Stainless Steel	Bronze / Stainless Steel
2	Casing	Cast Iron GR FG 200 / Ductile Iron	Cast Iron GR FG 200 / Ductile Iron	Cast Iron GR FG 200 / Ductile Iron
3	Shaft	EN-8 Steel	EN-8 Steel	EN-8 Steel
4	Shaft Sleeve	EN-8 Steel	EN-8 Steel	EN-8 Steel
5	Impeller Ring	SS 316	SS 316	SS 316
6	Casing Ring	Cast Iron GR FG 200	Cast Iron GR FG 200	Cast Iron GR FG 200
7	Stuffing Box Packing	Graphited Asbestos	Graphited Asbestos	Graphited Asbestos
8	Base Plate	Fabricated MS	Fabricated MS	Fabricated MS
D	Accessories			
1	Companion Flanges	Yes	Yes	Yes
2	Foundation Bolts	Yes	Yes	Yes
3	Base Plate	Yes	Yes	Yes
4	Inertia Blocks with Spring Isolators / necessary arrangement to avoid transfer of vibration	Required.	Required.	Required.

5.20 Technical Requirements for Air cooled chiller:

- All the pumps (primary and secondary) are in Terrace. Vertical In-Line Centrifugal type pumps are considered.

- Primary constant and Secondary variable type pumping system is considered.
- Control valves are considered which will modulate the chilled water flow based on the internal load requirement.
- Differential pressure sensors located in the CHW lines shall give signal to Pump PLC to reduce or increase the pump speed based on the line pressure.
- Multiple vertical risers have been planned for comfort application.

Parameter	Primary Pumps	Secondary Pumps
Flow Rate (GPM) &Qty (Nos)	360 GPM & (1W + 1S)	360 GPM & (1W + 1S)
Head	15 m	30 m
Type	Vertical Inline & Constant Speed	Vertical Inline & Variable Speed
Location	Plant room at Terrace level	Plant room at Terrace
Efficiency Class	IE-4	IE-4

5.21 DATA TO BE FURNISHED BY THE CONTRACTOR AFTER THE AWARD OF CONTRACT

- Quality Assurance Plan (QAP)
- Dimensioned general arrangement drawing of pumps and driver
- Foundation drawing of pump and driver with static and dynamic loads, details of fixing, grouting and all relevant data required for design of foundation.
- Cross-sectional drawings of the pump with complete part list, material of construction and relevant standards for each part.
- Pump performance curves flow rate Vs head, BkW, efficiency, NPSHR from zero flow to maximum flow and torque-speed curve.
- Scheme for pump sealing, lubrication and cooling.

- Driver dimensional drawing.
- Surface preparation and painting procedures.
- Catalogues, data sheets and drawings for instruments.
- Installation, operation and maintenance manual.

7. AIR HANDLING UNITS**7.1 SCOPE**

The scope of this section comprises the supply, erection, testing and commissioning of double skin construction air handling units, conforming to these Specifications and in accordance with requirements of drawings and of the Schedule of Quantities.

7.2 TYPE

The air handling units shall be double skin construction, draw-thru type in sectionalized construction consisting of blower section, coil section(Cooling & Heating), humidification section (where specified), filter section, and insulated drain pan, mixing box (wherever the return air and fresh air are ducted) as shown on drawings and included in schedule of quantities.

7.3 CAPACITY

The air handling capacities and static pressure shall be as shown on Drawings and in Schedule of Quantities.

- i) The capacity of the cooling/heating coil, the air quantity from the blower fan and static pressure of blower fan shall be as laid down in the tender documents. Where these parameters as calculated by the tenderer exceed the specified values, the coils and the blower fan shall satisfy these calculated values.
- ii) The coil shall be designed for a face velocity of air not exceeding 500 fpm.
- iii) The requisite static pressure demanded by the air circuit shall be developed by the fan at the selected operating speed. The static pressure value shall not in any case be less than 40 mm water gauge in normal cases, not less than 75 mm water gauge where (-ISO Coarse Grade with efficiency greater than 60%(confirming to ISO16890) & ISO ePM1 with PM efficiency (50%-70%) (confirming to ISO16890)) filters are also used and not less than 100 mm water gauge where absolute filters are also used. The fan motor HP shall be suitable to satisfy these requirements and the drive losses.
- iv) The air outlet velocity from the blower fan shall not exceed 1800 FPM.
- v) Noise level at a distance of 1.5 M from AHU shall not exceed 75 dBA.

7.4 CASING

- The casing of the air handling unit shall be of double skin construction, complying with EN 1886 or AHRI 1350 or ISHRAE standard for mechanical characteristics. The structure shall be made of Extruded Aluminium sections with polyamide thermal break profile for ensuring thermal bridging performance. The polyamide strip should be crimped to extruded aluminium sections for leak proof fitment. The structure shall be assembled using die cast Glass filled Nylon joints to make a sturdy, strong & self-supporting framework for various sections. The profile shall have built in coved aluminium profile having smooth curvature from inside to avoid dust accumulation.
- Double Skin Panels shall be minimum min 48 ± 2 mm thick constructed as follows
- Outer skin
- Pre-painted Galvanized Sheet Steel of 0.8 mm thickness with PVC guard film.
- Inner skin
- Aluzinc Sheet or plain GI sheet of 0.8 mm thickness having 270 GSM zinc coating.
- The outer and inner skin shall be sandwiched with self-extinguishing CFC – HFC free PUF insulation (density 40 kg/m³ with K factor not exceeding 0.02 Watt/mk). The panels shall be screwed to the structure using soft food grade gasket to make it leak proof. Air tight access doors/panels with die cast zinc hinges shall be provided for access to various sections for maintenance.
- The door shall be fitted with double wall inspection window of 200 mm diameter and robust glass filled nylon handles operational from both sides with optional locking arrangement. Each section should have inspection doors with duly wired marine lights and on/off switch mounted on wall of the unit. The entire housing shall be mounted on Rolled Formed channel made out of 270 gsm zinc coated heavy duty GSS channel frame work with provision for handling the units at site.
- Drain Pan shall be constructed of 18 G 304 Stainless Steel with dual slope to facilitate immediate discharge of condensate. Specially designed drain pan with all round edges allow complete cleaning & avoid microbial growth as per ASHARE 62 standard. The drain tray will be insulated externally with 19 mm nitrile rubber & extended at least 300 mm beyond the coil. Necessary arrangement will be provided to slide the coil in the drain pan.

- Mechanical performance of AHU casing shall be tested as per EN1886 or AHRI 1350 or ISHRAE standard by internationally renowned laboratory or certification body like AHRI/ Eurovent / Intertek / UL and should meet the following characteristics.

Mechanical Characteristics	As per EN 1886	As per AHRI 1350	As per ISHRAE Standard
Mechanical Strength	D1	CD 4	M1
Thermal Bridging	TB2	CB 2	TB 2
Thermal Transmittance	T2	CT 2	T 2
Air Leakage	L1	CL 2	CL 1

7.5 MIXING BOX

AHU's requiring mixing boxes as specified in Schedule of Quantities shall be complete with fresh and return air dampers.

7.6 DAMPER

Dampers shall be opposed blade type. Blades shall be made of double skinned aero-foil aluminum sections with integral gasket and assembled within a rigid extruded aluminium alloy frame. All linkages and supporting spindles shall be made of aluminium or nylon, turning in Teflon bushes. Manual dampers shall be provided with a Bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorized operation. Damper frames shall be sectionalized to minimize blade warping. Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.

7.7 PLUG FAN WITH EC MOTOR

- The complete EC Fan unit shall be of rugged bolted construction made of sheet steel, statically and dynamically balanced.

- **Fan:** The fan section shall be equipped with a Single Inlet Centrifugal Impeller with High Efficiency Backward curved blades and external rotor EC (Electronically Commutated) motor, energy optimized for operation without spiral housing for high efficiency and favorable acoustic behavior. The high efficiency backward curved impeller with rotating diffuser, made of high-performance composite material / welded aluminum sheet material, with external rotor motor balanced together statically and dynamically according to DIN ISO 1940 Part 1. The EC fan should be capable of being fitted in horizontal or vertical position in the AHU, depending on the application. Inlet cone shall be provided with a nozzle for volume flow measurement of the fan.

AHU manufacturer should supply cover plate for EC Fans in sufficient quantity for maintenance purpose.

- **Motor:** the motor shall be permanent magnet external rotor motor with integrated electronics and suitable for continuous operation. The speed of the motor shall be variable depending on an external control signal. The fans shall be Modbus RTU compatible for communication with BMS (Building Management System). The fan in totality shall be of most efficient type so that the power consumption and noise level is minimal. The EC motor shall have a wide voltage input range: 3~380...480V, 50/60 Hz. The motor shall be minimum IP54 protection class, with Thermal class 155 (Insulation class F). The EC motor shall be provided with suitable protection from moisture & hot climate. The ball bearing shall be provided with long time lubrication for maintenance free operation.

The EC motor shall meet all necessary EMC (Electromagnetic Compatibility) directives. The EC motor should comply to applicable EMC standards: Interference

Emission Standard EN 61000-6-3 / 2. EC Motor shall be Integrated with VSD (Variable Speed Drive) for speed modulation of fans.

The EC motor shall have the following protective features integrated in the controller:

- Overvoltage protection
- Short Circuit protection
- Under voltage/ Over voltage detection
- Locked rotor protection
- Line fault detection
- Alarm relay 250V/2A

Over temperature protection of electronic and motor

External LED display shall be provided for indication of the status of the fan

7.8 COOLING AND HEATING COILS

- Chilled water and Hot water coils shall have 12.5 to 15 mm dia (O.D) tubes made from seamless solid drawn copper minimum 0.5 mm thick with 0.15 mm thick sine wave aluminium fins firmly bonded to copper tubes assembled in 304 Stainless Steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and such that the air velocity across the coil shall not exceed 500 fpm. The chilled water coil shall be 6-row or 8-row deep coil and the hot water coil shall be 2 rows deep per the bill of quantities. In case of 8 rows deep coils, it shall be made of 2x4 rows deep coils with a spacing of 200mm between the two coils, access door and independent drain pan. The coil shall be pitched in the unit casing for proper drainage. The coil shall have copper header with chilled water supply & return connections protruding out of AHU casing by minimum 150 mm and fitted with dielectric coupling for connection with MS pipes. Each section of the coil shall be fitted with flow and return headers to feed all the passes of the coil properly. The headers shall be of copper and shall be complete with water in/out connections, vent plug on top and drain at the bottom. The coil shall be designed to provide water velocity between 0.6 to 1.8m/s in the tubes. Each coil shall be factory-tested at 21 kg per sq. m air pressure under water. Tube shall be mechanically expanded for minimum thermal contact resistance with fins. Fin spacing shall be 11 - 12 fins per INCH. The fins shall be evenly spaced and upright. The fins bent during installation shall be carefully realigned. Water pressure drop in coil shall not exceed 10 PSIG.
- **The cooling / heating coil shall be provided with hydrophilic coating.** Computerized cooling / heating coil selection output shall be submitted, and all Coils shall be AHRI certified. Stacked coils shall have an Intermediate drain pan made from 304 grade stainless steel, extending to the entire finned length of the coil. Cooling coils in stacks- section shall not be acceptable unless provided with an intermediate drain pan. The intermediate drain pan shall have drop tubes to guides condensate to the main drain pan.
- Pre Filters (WHEREVER SPECIFIED IN BOQ)
- Each unit shall be provided with a ISO 9001: 2015 factory assembled filter section containing 50mm thick disposable air filters having aluminium extruded mill finished frame. The filter shall have minimum efficiency of ISO coarse greater than 60%. The media shall be blended polyester in pleated construction or supported with HDPE mesh on one side and aluminium

mesh on other side. Filter banks shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter framework shall be fully sealed, constructed from aluminium alloy or aluminium extruded mill finished frame. Face velocity across these filters shall not exceed 500 FPM. Each filter shall carry certificate from manufacturer for the ISO 16890 Conformity and a sample test report. The filter area shall be made up of panels of size convenient for handling. The filter testing method shall be as per ISO 16890 latest edition.

Design Parameters of Filters

Parameter	Filter
Type	Box Type or Flange Type
Grade	ISO Coarse Grade with efficiency greater than 60%(confirming to ISO16890)
Initial P (mm WG) - clean condition	7.5+/- 15%mm WC – Initial Pressure Drop
Final P (mm WG) - clogged condition	20mm WC – Final Pressure Drop
Casing	Aluminium Anodized
Sealing of medium	Epoxy or equivalent
Medium	The media shall be blended polyester in pleated construction or supported with HDPE mesh on one side and aluminium mesh on other side.
Test Method	The filter testing method shall be as per ISO 16890 latest editions.
Disposable	Yes
Test certificate from manufacturer	Yes

7.9 FINE FILTERS (WHEREVER SPECIFIED IN BOQ)

Each unit shall be provided with a factory assembled filter section containing 300mm thick bag type synthetic media type air filters having anodized aluminium frame. The filter shall have minimum MERV 13 Rating. Filter banks shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter framework shall be fully sealed and constructed from aluminium alloy. Face velocity across these filters shall not exceed 500fpm. Each filter shall carry test certificate from manufacturer. The filter area shall be made up of panels of size convenient for handling. The filter testing method shall be as per ASHRAE 52.1 latest edition. Design Parameters of Filters.

Parameter	Filter
Type	Flange/ Box type
Grade	ISO ePM1 with PM efficiency (50%-70%) (confirming to ISO16890)
Initial P (mm WG) - clean condition	7.5 ± 15% mm WC – Initial Pressure Drop
Final P (mm WG) - clogged condition	20mm WC – Final Pressure Drop
Casing	Aluminium Anodized
Sealing of medium	Epoxy or equivalent
Medium	The media shall be blended polyester in pleated construction or supported with HDPE mesh on one side and aluminium mesh on other side.
Test Method	The filter testing method shall be as per ISO 16890 latest editions.
Disposable	Yes
Test certificate from manufacturer	Yes

7.10 UVGI FOR AHU COILS**A) General:**

The UVGI System shall be provided with the primary objective of achieving substantial reduction in microbial count, both airborne and on the surface of cooling coil.

B) Selection Criteria :

- a) The UVGI system shall be designed to cover the entire face area of the cooling coil and to achieve UVC (254 nm wavelength) irradiation with an exposure time of 15 minutes at irradiation intensity of 4016 $\mu\text{W}/\text{cm}^2$ based on ISHRAE recommendation.
- b) The lamps shall not operate at wave length 180 nm or lower, to ensure no uncontrolled ozone is put out by the lamps.
- c) The face velocity of dehumidified air over the coil will not be more than 500 FPM.
- d) The UVGI system shall be designed to achieve log 2 deactivation of microbial growth on the cooling coil. Subsequently, the UVGI system switching based on site requirement can be done to ensure that the microbial growth does not re-occur.
- e) The number of lamps in an UVGI System shall be calculated to ensure the minimum Average Intensity of 100 $\mu\text{W}/\text{cm}^2$ on the surface of cooling coil is achieved.
- f) Selection criteria of UV lamps to achieve the required parameters shall be got approved from Engineer In charge.
- g) An undertaking from manufacturer regarding rectification/replacement of UV Lamps during effective life as specified by manufacturer shall be provided by successful tenderer.

C) Specifications :**General :**

- a) The UVGI system shall be suitable to operate with 220-240 V, single phase A.C. supply. The power supply to the system shall be made available from AHU panel by contractor.
- b) The entire UVGI system shall be factory tested with test certificate from the reputed Lab. 3rd party test certificate can be provided either by contractor

- c) The UVGI system shall be installed in front of cooling coil with lamp facing coil to cover the drain pan.
- d) The selection and placement of the UVGI system shall ensure full irradiation of the entire face area of the cooling coil and drain pan.
- e) The UVGI System shall be free standing and be mounted in such a manner that lamps are in perpendicular plane to air flow.
- f) The electronic driver shall be installed in the control panel outside the AHU to avoid any effect on the electronic components due to moisture and to avoid additional heat generated load in AHU.

UV Lamps: The UV lamps shall meet following criteria:

- a) Lamp shall be High Output Quartz type, with current efficient.
- b) The lamp shall produce UVC as required to achieve the required parameters.

Support and framework:

- a) The entire framework and support inside AHU shall be fabricated out of Aluminum Alloy. All material used shall be UV resistant.
- b) The framework shall be free standing and suitable for quick assembly.
- c) The reflectors shall be in Aluminium Alloy of high UV reflectivity and parabolic in shape.
- d) All parts should be corrosion resistant.

Control Panel : Shall consist of the following :

- a) Electronic ballasts with high power factor of > 0.90 , High output Lamps required which will working on 800Ma.
- b) The ballasts shall be constant current output ballast over input voltage range of 190 to 270 VAC, single phase.
- c) Microprocessor based control panel with LCD Display.
- d) Individual Lamp run hours for timely and easy replacement
- e) Individual lamp On/Off/Error Indicator
- f) Real Time Clock to have the exact time and duration of the system and individual lamps.
- g) Programmable Real time On/Off switching for system
- h) Shall be BMS Compatible
- i) Ballast Protection Circuit
- j) Lamp change reminder on Display
- k) ON/Off for incoming power - Mains Power

Safety :

- a) Ballast Protection Circuit is provided in Control panel to ensure ballast is turned off for protecting it after 2 minutes if the lamp does not start.
- b) Fire resistant FRLS cables.
- c) Proper UV caution labels shall be applied to control panel and on the AHU sides and strategic points.

Certificates:

The contractor shall provide manufacturer's test certificates for main items like lamp, ballast, system etc.

Installation:-

The UVGI lamps shall be mounted on a self-supporting rigid frame and the flow of air shall be perpendicular to the direction of air flow.

All safety and certification from UL/CE will be attached with the technical submittal of the system.

Testing & Commissioning:

The intensity of the UV Lamps across the coil will be measured using a calibrated radiometer.

7.11 ACCESSORIES

Each air handling unit shall be provided with manual air vent at high point in the cooling coil and drain plug in the bottom of the coil. In addition, the following accessories may be required at air handling units, their detailed specifications are given in individual sections, & quantities separately identified in schedule of Quantities.

Insulated butterfly valves, balancing valves, 'Y' strainer, union & condensate drain piping with 'U' trap up to sump or floor drain in air handling unit room, as described in section "Piping".

Thermometers in the thermometer wells & pressure gauge (with cocks) within gauge ports in chilled water supply and return lines as per the section "Instruments".

7.12 PAINTING

Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with paint to match the finish over the adjoining shop painted surface.

7.13 INSTALLATION

The air handling unit shall be so installed as to transmit minimum amount of vibration to the building structure. Adequate vibration isolation shall be provided by use of rubber/ neoprene pads and/or vibration isolation spring mountings.

8. PRECISION AIR CONDITIONING UNIT (PAC)**8.1 SCOPE OF WORK**

The Scope of Work covers the supply, installation, commissioning, and warranty of Precision Air conditioner (herein referred to as “product”) and services provided for the same.

8.2 GENERAL

The AC Units should have high sensible heat ratios, to match high sensible loads of Computer/Server Rooms/ Switch room/UPS. A Microprocessor controlled Precision package AC system.

The Indoor unit shall be of CHW type comprising of corrosion resistant composite material EC fans, Chilled Water-Cooling Coil with hydrophilic coating, Microprocessor controllers, 90% down to 5-micron filter, Internal power and Control wiring, Heaters, Power and Control contactors and Other Electrical accessories.

8.3 8.3 DESIGN REQUIREMENTS

The environmental control system shall be Factory assembled unit. It shall be floor mounted, optimized for maximum cooling capacity in a minimum footprint. It shall be specifically designed for service from the front of the unit. The system shall be designed for draw-through air arrangement to insure even air distribution to the entire face area of the coil. The unit shall modulate cooling capacity and airflow based on requirements.

The unit shall be ready to allow the installation of shackles for top handling. Forklift handling should be possible as well.

8.4 QUALITY ASSURANCE

The specified system shall be factory end of line tested (functionality test) before shipment and designed to meet CE requirements. The system shall be designed and manufactured according to world-class quality standards. The manufacturer shall be ISO 9001 certified.

8.5 CABINET

The cabinet shall be manufactured from galvanized steel sheet, externally painted with colour epoxy-polyester powder paint, and assembled using stainless steel screws and high tensile rivets.

The Side and rear section panels shall be double-skinned, with Class 'O' (A1 EU) fireproof insulation sandwiched between the skins to reduce noise emission and heat loss. The frontal panel(s) are assembled on hinges to make the access easier; this can be opened by the fast-closing lock.

The rear and side panels are screwed to the supports. The rear panel(s) are screwed directly to the frame.

8.6 COOLING CIRCUITS

- The unit shall house Chilled water inclined evaporator coil shall be manufactured from copper tubes, mechanically bonded to hydrophilic painted aluminium fins, with a stainless-steel coil casing & condensate drain pan with insulation. The coil shall be designed for large face area-low velocity that facilitates precise control of temperature and humidity during cooling and dehumidification & optimizes fluid velocity and minimize pressure drop.
- For units with multiple circuits, the evaporator shall be staged coil to allow a maximum efficiency on partial loads.
- Chilled water coils shall have 12.5 mm dia (O.D) tubes made from seamless solid drawn copper minimum 0.5 mm thick with 0.15 mm thick sine wave aluminium fins firmly bonded to copper tubes assembled in zinc coated steel frame. Coils with 9.54 mm dia (OD) shall be acceptable only if Water Side pressure drop is within 30 kPa. Face and surface areas shall be such as to ensure rated capacity from each unit and such that the air velocity across the coil shall not exceed 500 fpm. The chilled water coil shall be 4/6-row deep coil. The coil shall be pitched in the unit casing for proper drainage. The coil shall have copper header with chilled water supply & return connections protruding out of casing by minimum 150 mm and fitted with dielectric / flanged coupling for connection with MS pipes. Each

section of the coil shall be fitted with flow and return headers to feed all the passes of the coil properly. The headers shall be of copper and shall be complete with water in/out connections, vent plug on top and drain at the bottom. The coil shall be designed to provide water velocity between 0.6 to 1.8m/s in the tubes. Each coil shall be factory-tested at 21 kg per sq. m air pressure under water. Tube shall be hydraulically/ mechanically expanded for minimum thermal contact resistance with fins. Fin spacing shall be 11 - 12 fins per INCH. The fins shall be evenly spaced and upright. The fins bent during installation shall be carefully realigned. Water pressure drop in coil shall not exceed 5 m of H₂O.

8.7 FAN SECTION

- The unit shall be fitted with one (two, three as per airflow requirement) direct-driven, high efficiency, single inlet, backward curved, centrifugal 'plug' type innovating EC fan(s).
- The fan motors are Electronically Commutated, IP54, with internal protections, continuous speed regulation via controller signal. The motor is three-phase with IP54 protection; provided with internal thermal protection.
- The fan wheel is statically and dynamically balanced; the bearings are self-lubricating.
- Fan(s) removal(s) shall be made faster using the buttonhole specifically designed and tested to allow 10 cm increasing height during the operation.

8.8 HEATING

The heating resistors should follow rigid design for extended operational life and to be normally utilised to maintain room dry-bulb conditions during a system call for dehumidification. Each heating element of heaters is made of finned armoured stainless steel AISI 304 / Inconel to maintain a low surfaces power density. Ionization effects are eliminated owing to the low heater surface temperature.

Heating control shall be of the ON-OFF type. The heaters should be phase balanced and provided with a manual reset safety thermostat to disable them in the event of a high temperature.

The heating system should also incorporate Miniature Circuit Breaker(s) & fuse which protects the heater(s) from short circuits, should the harness be damaged accidentally.

8.9 AIR FILTRATION

The filter chamber shall be an integral part of the system and withdraw able from the front of the unit. Filtration shall be provided by dry media disposable filters capable of filtering air to 95% down to 5-micron efficiency and shall be replaceable from the top of the unit. Filtration shall be provided by deep V form G4 performance dry disposable media to ASI324

8.10 DAMPER

Dampers shall be Aluminium opposed blade type. Blades shall be made of double skinned aero-foil aluminium sections with integral gasket and assembled within a rigid extruded aluminium alloy frame. All linkages and supporting spindles shall be made of aluminium or nylon, turning in Teflon bushes. Manual dampers shall be provided with a Bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorized operation. Damper frames shall be sectionalized to minimize blade warping. Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.

8.11 MONITORING

The unit shall be supplied with card suitable for both SNMP & ModBus connectivity.

The unit shall also include input for remote on-off and volt-free contacts for simple remote monitoring of low and high priority alarms: high/low temperature, fan/control failure, and others are available.

8.12 ELECTRICAL PANEL

The electrical panel, located at the front of the unit in a compartment isolated from the airflow, contains the MCB's, contactors, transformers, controller PCB, overload relays etc. Each high voltage system component is provided with an MCB over-current protective device. All high voltage components are touch protected by means of a plastic cover.

The electrical panel complies with the IEC norm en60204-1. Electrical power supply is 400V ($\pm 10\%$) / 3Ph / 50Hz ($\pm 2\text{Hz}$) +N +E and are fitted with a mains isolator, mechanically interlocked with the electrical panel cover.

8.13 MICROPROCESSOR CONTROLLER

- The Control System is P/PI/PID microprocessor based. It can be programmed to control the function of every device within the unit via I/O.
- The controller allows setting and monitoring of the following room parameters via a 3-button keypad:
 - Air Temperature
 - Temperature set-point
 - Temperature band
 - Humidity
 - Humidity set-point
 - Humidity band
- The parameters are indicated using symbols and text on a backlit, 3 digits Liquid Crystal Display. Cooling and heating modes are also indicated on the LCD screen. Alarm conditions activate a visual indicator. Three LEDs indicate the unit status – 'Power on' (Yellow), 'Unit on' (Green) and 'Warning/Alarm activated' (Red)
- The controller shall provide **Unit to Unit Ethernet connection** to operate with multiple units, run/stand-by rotation, automatic changeover and parameter sharing functions, external communications through BMS Modbus RS 485, sequential auto restart timer, with

adjustable time delays to be applied to unit restart after a power loss. The Unit shall be compatible for Modbus / BACnet over IP

- The following warnings / alarms are included:
 - High temperature
 - Low temperature
 - High relative humidity
 - Low relative humidity
 - Fan failure
 - Electrical heater high temperature (When applicable)
 - Sensor failure
 - Controller errors
- Terminals are provided for remote start/stop control plus Volt-free 'Common Alarm' and 'Unit Run' indication
- The display shall provide with track recorded of temperature and humidity with graphically display on the screen.
- A buzzer provides audible indication of a 'Warning' or 'Alarm' condition
- Unit memory shall hold the 200 most recent alarms with time and date stamp for each alarm
- Unit memory shall hold the 400 most recent events with id number, time, and date stamp for each event
- Menu shall display accumulative component operating hours for major components including compressors, fan motor, humidifier and reheat.

- The controller shall facilitate auto sequencing of units in the given zone, team mode operation, master- slave configuration, auto changeover of master unit in an event of master unit failure, cascade operations 7 lead-lag operation

8.14 SAFETY INTERLOCKS

Operation of heaters & humidifiers shall be possible only when blower fan is in operation. Fire detection signal from fire detector system shall be able to switch off the package unit operation in event of fire in conditioned space. The Motorized Damper supplied along with the unit shall be checked before turning the unit ON/OFF.

8.15 ELECTRICAL WORK

Each Precision AC unit should be provided with in-built electrical panel. Necessary 415 Volts +/- 10%, 3 Phase, 4 Wire (With Neutral), 50 Hz +/- 5% Power shall be provided by Customer at each unit's electrical panel. Balance distribution of Power is in the Scope of Bidder. All Electrical cabling should be of armoured Copper.

8.16 VIBRATION ISOLATORS

The PAC units shall be provided with ribbed rubber pad vibration isolators both between the Unit & Stand & between the Stand & the Finished Floor

8.17 PAINTING

PAC - units shall be factory finished with durable alkyd spray enamel / powder coating. Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, then coated with enamel paint to match the finish over the adjoining shop-painted surface.

8.18 PERFORMANCE RATING:

The unit shall be selected for the lowest operating noise level (68 dBA at 1.5m). Capacity rating and power consumption with operating points clearly indicated shall be submitted and same shall be verified at the time of testing and commissioning of the installation. For site verification of working of humidification / dehumidification systems, set point RH shall be changed below / above (respectively) actual RH. Similar procedure shall be adopted for temperature control system. Test report shall indicate selected set point for RH and temperature and achieved values of these process variables after humidification / dehumidification cycles are activated.

9. TWO STAGE EVAPORATIVE COOLING UNIT

An Indirect-Direct evaporative cooler consists of 2 stages of cooling. Indirect section is the first stage of cooling, which lowers both dry bulb and wet bulb temperature of the incoming supply air. This supply air is then passed through a direct section evaporative cooler which provides the second stage of cooling. The first stage of cooling is at constant humidity level, while the second stage is at constant wet bulb temperature. A reservoir purges and drains during off cycles to prevent biological growth.

9.1 INDIRECT SECTION

Indirect sensible cooler with a complete secondary evaporative cooling system includes components of heat exchanger, evaporative media, re-circulating pump, sump drain, overflow, automatic fill and level control, secondary air exhaust fan and internal piping. House all components in a common casing.

- **Heat Exchanger**

The indirect section shall have approved make DAMA heat exchanger module to effect minimum sensible cooling of 80% for peak summer design conditions. This heat exchanger module shall be made up of engineering polymer with a cellulosic media fused in one side of plates of heat exchanger. Each heat exchanger module need to be stacked up modularly to required air capacity. These heat exchanger modules shall facilitate a secondary air passage without mixing with the primary air flow. Construct media of refined cellulose fibers impregnated with insoluble anti-rot salts and rigidifying saturates. The efficiency of this heat exchanger should have been tested & validated by UL. Vendor need to submit the performance curve.

- **Re-Circulation pumps**

The recirculation pump should be of SS 304 submersible type and of approved Ebara make. The pump should be designed such that it can handle the designed amount of water flow and maintain required head. There should be two different pumps, one for indirect evaporative system and other for direct evaporative system. The pumps should be designed such that pump shaft horsepower (BHP) shall not exceed motor rated horsepower throughout the entire operating range of the pump performance curve. Pump shall be built to operate.

The pump shall be furnished with a non-mechanical double oil seal.

The pump motor shall be minimum 1/3HP, 0.3 Kw, 230 Volts, 50 Hz single phase motor. The motor shall be supplied with built-in thermal protection with automatic reset and shall be rated for continuous duty.

All internal piping shall be of UPVC.

- Filters

The filters shall comprise of HDPE filters of cell/box type construction with 85% efficiency down to 10 microns. The filters should be slidable and washable.

9.2 DIRECT SECTION

- Direct Evaporative Media

The media shall be celdek with Thickness of 200 mm in case of 7mm flute. The water tank shall be made up of 18SWG (1.2mm) thick SS 304 plain sheet to house both sensible and adiabatic heat exchangers.

The water tank shall be designed as chassis to hold the heat exchangers support system. The water distribution system shall be designed properly to get proper efficiency across the heat exchangers. The piping shall be used of rigid UPVC material. Piping connections should be made so as to ensure uniform distribution of water. The sump shall be fitted with float valve.

- U-V Filter

Provide UV filter for re-circulation line. UV filtration controls the bacterial disinfections in the supply water line thereby restricting the growth of algae and fungus. The capacity shall be based on the flow rates of individual machines.

9.3 BLOWER SECTION

The blower section shall include AMCA certified centrifugal Backward curved DIDW / Plug fans as per BOQ. The unit shall be of GI construction. It shall have individual motor and drive and shall be mounted on C channel frame and cushy foot mounts. The fan shall be constructed and rated based on the delivery against the rated static pressure with the media and filters in place. The fan shall be of riveted construction and made with GI sheet of required thickness. The fan wheels shall be of multiblade type and mounted on two self aligning pillow block bearings of required size. The fan shall be run with the help of 'V' groove drives as per the recommendation of the drive supplier. The blower housing shall be

made of machine made roll formed Pittsburgh joint construction and the drive shall be provided by a motor of required capacity.

9.4 COMPONENT CASING

Blow through design is required for the unit. Exterior panels shall be removable to permit access to any interior component. The unit will be sectionalized double skin construction made out of 0.63mm white pre-coated GI outer skin, 0.63mm GI inner skin, 23 +/-1 mm CFC free PUF Insulation to density of 38-42Kg/m³. The structural construction shall be extruded aluminum profile. The skid will have necessary cross members to take care of the load of fan blower assembly. All the components of the unit will be of proper design and quality to ensure vibration free and noiseless operation. PVC Mist eliminators to be provided. Machine bottom shall be with 2mm thick Aluminum chekered plate.

9.5 MOTOR

Motors shall be IE2 (EEF-1) type of ABB/Siemens/CG approved make.

9.6 CONTROL PANEL

Should be in-line with IP-55 suitable for outdoor installation. Electrical panel should control temperature and Rh. Panel shall be Non - Compartmentalized panel and should have RYB indication -Indication lamps, Incomer-SFU Blower/Pump controls- Thru' -MPCB, Contactor with OLR, Digital display- VAF meter, ATE-PLC - for logic control, Sensor- Temp./Rh for logic control (4-20mA). VFD to be provided in panel.

Panel should take care of auto cutoff of pumps based on temperature and Humidity parameters set in PLC. It should have both Auto and Manual mode. It should have light indicator with push buttons for each component i.e. Primary fan, Pump 1 and Pump 2 that shows On – Off – Trip status.

10. VENTILATION FANS**10.1 SCOPE**

The scope of this section comprises the supply, erection, testing and commissioning of ventilation fans conforming to these Specifications and in accordance with the requirement of Drawings and Bill of Quantities.

10.2 TYPE & CAPACITY

Centrifugal, in-line and propeller fans shall be of the type and capacity as indicated on Drawings and identified in Bill of Quantities.

10.3 CENTRIFUGAL CABINET FAN

- Centrifugal fan shall be DIDW / SISW type complete with access door, squirrel-cage induction motor, V-belt drive, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved-for-Construction shop drawings. Fan contained within the cabinet shall be AMCA Air and Sound Certification.
- Casing - The casing for air handling unit shall be of double wall construction with 25 ± 5 mm thick polyurethane foam or equivalent fire retardant insulation (CFC and HCFC free) sandwiched between the panels. The density of the insulation material shall be $40 \pm 2 \text{ kg/m}^3$ and the thermal conductivity does not exceeds $0.02 \text{ W/m}^2\text{C}$ The inner wall shall be of 0.6mm plain galvanized sheet steel. The outer wall shall be of 0.6mm galvanized sheet steel. It shall be rigidly reinforced and supported by structural angles. Split casing shall be provided on larger sizes of fans, however neoprene / asbestos packing should be provided throughout split joints to make it air-tight. The minimum space between the fan inlet and panel shall be one fan dia.
- Filter Section - Each fresh air fan unit shall be provided with factory assembled filter section containing filter having anodized aluminium frame. Filter bank shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter framework shall be fully sealed and constructed from aluminium alloy. The filter shall be EU-4 (MERV-9) or better. The filtration efficiency shall be as per ASHRAE 52.2 standards. Necessary access door shall be provided for accessing the filter sections.

- Housing shall be provided with standard cleanout door with handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.
- Fan Wheel shall be forward / backward-curved non-over loading type. Fan wheel and housing shall be statically and dynamically balanced. For fans upto 450 mm dia, fan outlet velocity shall not exceed 550 meter/minute (1800 fpm) and maximum fan speed shall not exceed 1450 rpm. For fans above 450 mm dia, the outlet velocity shall be within 670 meter/minute (2200 fpm) and maximum fan speed shall not exceed 1000 RPM. High static pressure fan speed shall be as per manufacturer
- Shaft shall be constructed of steel, turned, ground and polished.
- Bearings: shall be of the sleeve / ball-bearing type mounted directly on the fan housing. Bearings shall be designed especially for quiet operation and shall be of the self-aligning, oil / grease pack pillow block type.
- Motor: Fan motor shall be energy efficient and suitable for $415 \pm 10\%$ volts, 50 cycles, 3 phase AC power supply, high efficiency (EFF-1) squirrel-cage, totally enclosed, fan-cooled motor, provided with class F insulation, and of approved make. Motor name plate horsepower shall exceed brake horsepower by a minimum of 10%. Motor shall be designed especially for quiet operation and motor speed shall not exceed 1440 rpm. The fan and motor combination selected for the particular required performance shall be of the most efficient (smallest horse power), so that sound level is lowest.
- Drive to fan shall be provided through belt with adjustable motor sheave and a standard belt guard. Belts shall be of the oil-resistant type.

10.4 INLINE FAN SPECIFICATIONS

- **INLINE FANS** shall be preferably be single inlet/ double inlet centrifugal fan with forward curved blades & external rotor motor. These fans shall be complete with casing, motor & impeller.
- **CASING** shall be constructed of GSS sheet metal construction. The casing shall be double skin internally acoustically lined and constructed of Galvanized Steel. The fan shall be SISW (dia 100 to 160) / DIDW (dia 200 to 500) with forward curved impeller fitted with maintenance

free external rotor motor. Fans should have an outer casing of hot-rolled galvanized sheet steel complying with EN 10142/ 10147. The sheet steel must have a layer of 20µm of zinc for protection against corrosion. Indication showing rotation arrow and make, model number and duty conditions of the fan shall be mentioned on fan casing.

- **FAN Impellers** should be backward curve/ forward curved having aluminum blades. The impellers should be press fitted directly onto the rotor of the external rotor motor. The motor and impeller should be balanced dynamically in two planes in accordance with DIN ISO 1940.
- **MOTOR** - Fan motor should be external rotor type motor with built in thermal contacts for protecting against overheating. Compact in size and its construction should allow motor to be cooled by transported air. Motor and impeller assembly should be mounted on a plate to facilitate easy removal and servicing.

Fan should be speed controllable in five steps.

- **Noise level** of fan should not be more than 40 dB(A) at 3 mtr distance.
- **Insulation** – Fan should be thermally and acoustically insulated with 50mm layer of rockwool with a surface liner which prevents the migration of fibers into the air stream.
- **Installation** – Fan must be able to install in any position and must be provided with mounting clamps to connect to duct.

All fans shall be selected for the lowest operating noise power levels. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation. All the technical data of fans should be approved as per AMCA & ISO standards.

10.5 PROPELLER FAN

Propeller fan shall be direct-driven, three or four blade type, mounted on a steel mounting plate with orifice ring.

- Mounting Plate shall be of steel construction, square with streamlined venturi inlet (reversed for supply applications) coated with baked enamel paint. Mounting plate shall be of standard size, constructed of 12 to 16 gauge sheet steel depending upon the fan size. Orifice ring

shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.

- Fan Blades shall be constructed of aluminium or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works.
- Shaft shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed thru the full range of specified fan speeds.
- Motor shall be standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with pre-lubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 1000 rpm for fans 60 cm dia or larger and 1440 rpm for fans 45 cm dia and smaller. Motors for larger fans shall be suitable for $415 \pm 6\%$ volts, 50 cycles 3 phase power supply, and for smaller fans shall be suitable for $220 \pm 6\%$ volts, 50 cycles single phase power supply. Motors shall be suitable for either horizontal or vertical service as indicated on Drawings and in Bill of Quantities.
- Accessories : The following accessories shall be provided with propeller fans :
 - Wire guard on inlet side and bird screen & rain protection cowl at the outlet.
 - Fixed or gravity louvers built into a steel frame at the outlet.
 - Regulator for controlling fan speed for single phase fan motor.
 - Single phase preventors for 3 phase fans.

10.6 AXIAL FANS

Fans shall be of the type, size, arrangement and capacity as indicated in the schedule and/or as shown on the drawings.

- Unless specified, fan performance rating data shall be tested accordance with AMCA Standard 210-85 (Air Moving and Conditioning Association), ANSI/ASHRAE Standard 51-1985 "Laboratory Methods of Testing Fans for Rating". Sound ratings shall conform to AMCA Standard 300-85, "Reverberant Room Method for Sound Testing of Fans".

- A computer printout of fan performance rating corresponding to the AMCA licensed data, with corrected ratings for altitude and temperature, fan operating speed, bearing life, etc. shall be submitted for approval.
- All fans shall be dynamically trim-balanced to ISO1940 and AMCA 204/3 - G2.5 quality grade after assembly. A computer printout with the vibration spectrum analysis shall be attached to the fans.
- Fan motors shall comply in all respects with continuous rating in accordance with IEC34 or equivalent. Motor bearings shall be of ball or roller type, grease or lubricant sealed for life. Fan and drive shall be earthed to prevent accumulation of static charge.
- Fans shall be installed at staircase or lobby where fresh air intake is free from any obstruction and shall be energized only by fire alarm system. Fan shall be of Axial Flow Fan. Protective grille at the suction of the fan is required.
- Fans for elevated temperature (Smoke Extraction Fans) with components rated for high temperature (250 deg C for 2Hrs) service, with belt drive assemblies exposed to the air stream are not acceptable.
- For Smoke Extraction Fans where motor is in the air stream with electrical/electronic temperature limit switch for motor protecting shall not be used.
- Fan should be of G.S.S. , the Steel sheet should be JFE Galva zinc (Base metal cold rolled), JIS G3302, SGCC with Z22 (minimum coating weight on both sides @ 220 g/m2) zinc coating & Zero Spangle, skin passed, chromate and dry.
- If fan is open to atmosphere, Fans shall be with pure polyester powder coating for minimum thickness of 60 microns.

Axial fans shall be complete with casing, motor, with impeller, Casing made of Galvanized steel Direction of discharge and rotation position shall be as per the job requirement and shall be marked on the fan assembly.

- a) **Casing:** Casing shall be constructed of Galvanized steel Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts.

- b) **Impeller:** Hub and blades shall be constructed of die cast aluminium alloy. Impeller should have aerodynamic profile to guarantee high efficiency and low noise level.
- c) **Motor:** Motor shall be suitable for 415V/ 50HZ/ 3Phase. Motor shall be specially designed for quiet operation. The speed of the fans shall not exceed 1440 RPM for fans with impeller diameter above 450 mm, and 2880 RPM for fans with impeller diameter 450 mm and less. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower.
- d) **Drive:** Drive of fan shall be direct driven.
- e) **Temperature Range:** 45degC for standard ventilation / 250 deg / 2H for smoke evacuation.

10.7 TECHNICAL SPECIFICATIONS OF JET FANS AND CFD.

a. **JET FANS**

Jet Fans shall be completely assembled at factory and then supplied to the site. Each jet fan shall be complete with motor, motor mount, silencers at inlet and outlet discharge, terminal box and mounting brackets to vibration isolation type suspension arrangement.

- b. **CASING** of JET fans shall be constructed of heavy gauge sheet steel as per DIN EN ISO 1641. Fan casing and motor mount shall be of welded steel construction. Casing shall be hot dip galvanized to protect against corrosion.
- c. **IMPELLER** of JET fans shall be constructed from die cast aluminum. Profiles of impeller blade should be of aerofoil type to have high efficiency and low noise levels. Aerofoil Fan impellers shall have a unique aerodynamic section blade to optimize the efficiency of performance and minimize the generation of noise. Impeller must be statically and dynamically balanced as per ISO 1940 grade 6.3
- d. **Temperature Rating** -The complete fan assembly with its casing, impeller and motor (not only motor or one of the item) shall be sourced from one manufacturer and certified and tested as per EN12101-3- 300 degree (572 F) for 2 Hrs operation. The fan shall have a non-overloading characteristic. The peak power inputs occurs within range of normal operating pressures and is always exceeded by motor rating.

- e. **FAN Motor** shall be energy efficient, squirrel cage, thermally enclosed, Class H insulation, continuous duty, Dahlander winding for dual speed applications suitable for 400V/3 Ph/ 50Hz, AC power supply. Motor shall comply with IEC34-a.
- f. **Terminal Box**- Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit. It shall be sealed with fire rated sealant.
- g. **Inlet Cone**- Jet fans shall have Inlet cone made of Galvanized steel
- h. **Protection Guard** should be provide at inlet side of Jet fan.
- i. **Silencers**- Noise level from Jet fan shall not exceed 52 dB(A) at 1 mtr distance. Silencers Casing should be rolled, pre-galvanized sheet steel with spun end rings incorporating tapped inserts for fixing. Absorbent material used should be of acoustic grade mineral fibre with a layer of erosion resistant facing and must be further protected by a sheet of pre-galvanized perforated steel.
- j. Minimum length of silencers should be 900mm.
- k. **Mounting Brackets**-Jet fans shall be supplied with mounting brackets for ceiling suspension.
- l. **Data Sheet –**

SL NO	DESCRIPTION	UNIT	Asper Design	Offered by Tenderer
1	Overall dia	mm		
2	Impeller Dia.	mm	350mm	
3	Capacity of fan	Cfm	Low/High speed - 1405/2815 CFM @ Low/High speed - 2900/5900	
4	Tip Velocity	m/s		
5	Phase	Ph	3 Phase	
6	Voltage	V	415 ± 10%	
7	Frequency	Hz		

8	Revolution	RPM		
9	Ampere	A		
10	Sound Level	dB(A)	52 dB(A) at 1 mtr	
11	Weight	Kg	60	
12	Power Consumption	KW	0.3/1.3 kw @ 4/2 Pole	
13	Depth of unit	Mm	Silencer min. length shall be 2 times of dia.	
14	Thrust	Nm		
15	Motor weather proof rating		IP20	
16	class of insulation		Class H	
17	Fire rating		300 Deg. C for 2 Hours	
18	Noise		57/71 @ Low/High speed @ 3m	
19	Motor & Fan Efficiency			

10.8 CFD Analysis-

- CFD (Computational Fluid Dynamics) is in a simplified version, a dynamic simulation of the behavior/ development of smoke, air speed, visibility and others, inside the car park, given certain conditions (airflows, temperatures etc.,).
- Computational fluid dynamics (CFD) can simultaneously predict airflow, heat transfer and contaminant transport in and around buildings. A CFD model is built upon fundamental physical equations of fluid flow and energy transfer. The technique is capable of providing time dependent and as well as steady state solutions to the coupled differential equations.

10.9 NOISE AND VIBRATION

Noise level produced by any rotating equipment individually or collectively shall not exceed 65 dB (A) measured at a distance of 1.5 meters from the source in any direction. The overall vibration level shall be as per zones A and B of ISO 10816-1. Balance quality requirement shall be G 6.3 conforming to ISO 1940/1.

10.10 PERFORMANCE DATA

All fans shall be selected for the lowest operating noise level. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

10.11 TESTING

Capacity of all fans shall be measured by an anemometer. Measured air flow capacities shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

11. OZONE GENERATORS**11.1 SCOPE.**

The scope of this section comprises the supply and installation of duct mounted Ozone Generator in STP exhaust ductwork for control of organic odor confirming to these specifications

11.2 GENRAL REQUIREMENTS.

- Ozone Generators shall be provided with the primary aim of achieving reduction in Volatile Organic Compounds (VOC), hydro carbon gases, and organic odours, in Indoor / outdoor environment. The aim is to ensure the pure and odourless air where ozone concentration shall be kept below the TLV (Threshold Limit Value) for occupied areas, as recommended by OSHA and or ACGIH.
- Ozone Generators shall be provided where called for, with number of corona discharge plates as listed in the schedules. Ozone Generators shall be compact, self-contained units, with all components factory mounted in one neat, compact package. Parts of the generators in contact with air stream shall be kept to as minimum as required.
- Components in contact with air stream shall be enclosed in stainless steel casing 18 G thick, with sufficient stamped integral openings to allow adequate flow of air over the corona discharge plates. The generator plates shall be mounted on generator head fabricated out of materials that repel accumulation and formation of sediments by tar, nicotine and grease. This is an extremely important prerequisite to enhance the operational reliability and ease of maintenance of the generator plates.
- The generators shall be suitable for mounting on ducts with air flow in horizontal, vertical or angular directions. The generators shall operate effectively with air flow in either direction, that is left to right or vice versa in horizontal ducts, and top to bottom or vice versa in vertical ducts.
- The generators shall be suitable for mounting inside the ducts. It shall be provided with flange suitable for mounting on a metal frame, to be installed inside the duct. Openings in the ducts shall be made with sheet metal shears or cutters. Metal saw or grinding machine

shall not be used, except to make an initial cut to permit use of metal shear. This precaution is taken to prevent metal debris from falling into the ducts.

- Air filter (efficiency 80%) shall be provided in the duct to prevent particulate in the air stream from reaching the ozone generator.
- Generation of ozone shall be only by principles of corona discharge. Multiple numbers of corona discharge plates shall be used to provide the necessary quantity of ozone. All the corona discharge plates shall be housed in one common stainless steel enclosure. Only multiple plate type corona surfaces shall be used for ozone generation. Production density of ozone per sq inch (or sq cm) of surface area of corona surface shall be as low as possible. Rate of variation of production of ozone shall follow approximately the rate of variation of fouling smell in the air flow.
- Ozone shall be detected in the same gaseous stream, and ozone production shall be in this stream. To ensure this, ozone generator shall be duct mounted type. Ozone generators shall not require any consumable for its operation, except for use of electricity.
- The system shall not rely on initial or replacement of filters of any sort to remove odours and chemicals. The ozone generators shall be capable of operating on 220 to 240 Volts, single phase power supply, 50 Hz. They shall be properly grounded.
- Ease of maintenance is important consideration. They shall be manufactured to permit easy withdrawals and refitting on the ducts, with minimum use of tools or hardware to remove or refit the generators to the ducts.

11.3 OZONE CONCENTRATION SENSOR, MONITOR AND CUTOUT SWITCH

- Ozone concentration monitor cum sensor shall be provided to monitor ozone concentration. The monitor shall be installed in a side stream duct and not in the main duct. This is to ensure the sensor element is not exposed to high velocity of air found typically in all HVAC ducts. This ensures accuracy of sensor readings, and prolongs life of the sensor element. Lowest detection of the monitor shall be down to 20 PPB (v) or 0.02 PPM (v).
- Visual display shall be provided on the outer case of the Monitor. This shall comprise series of at least 10 pilot indicating lights, 4 green, 3 yellow and 3 red. When illuminated, they indicate the concentration of ozone in the following order.

- First green: Always On. Indicates power is ON. Next 3 green lights: Concentration of 20, 30 and 40 PPB respectively. Three yellow lights: Concentration of 50, 70 and 80 PPB respectively. First red light: 100 PPB (Maximum specified by OSHA). Second and third red lights: 120 and 140 PPB respectively.
- The sensor, monitor and all components shall be mounted in one neat and compact case, suitable for wall mounting. The indicating lights shall be mounted on the cover of the case. All components shall be factory mounted.
- The monitor shall have electrical leads to provide an open contact. In the event concentration of ozone reaches the set alarm value, 'Normally Close' changes to 'Normally Open' position. This will be used to electrically cut out the ozone generator, when concentration reaches the set value.
- Additionally, it shall also have an audible alarm, which is activated if the concentration reaches the set level. Switch shall be provided on the case of the monitor, to turn off the alarm, at the option of the user. The alarm shall be factory set at 50 PPB. However, it shall be possible to change this setting in the field to any desired level.
- The monitor shall provide a linear 0 to 2 Volts DC output voltage, proportional to concentration of ozone. This will be interfaced with the BMS to record continuously concentration in PPB or PPM, and also to produce hard copy printouts. This will also enable shutting down the ozone generators through the BMS, if the set high level is reached.
- The monitor shall be capable of interfacing with BMS. Necessary transponders to enable this will be provided by others. It shall also be possible to set the high ozone cut out level through the BMS, and to shut down the ozone generators through BMS, in the event the set alarm is reached.
- The monitor shall be suitable for continuous operation. Input power source is 24 volts, DC, provided. Suitable adaptor for this shall be provided with the Monitor.

11.4 VARIABLE LOAD CONTROLLER

- Controller shall be solid state, mounted in rugged stainless steel enclosure. It shall be fully factory assembled. Field provided connections shall be limited to power wiring. The Controller shall be suitable for accepting signals from the Sensor. Based on the signals received, it shall provide variable output to operate ozonator.

- Input voltage to controller shall be 120 Volts, 1 Ph, 60 Hz or 220 to 240 Volts, 1 Ph, 50 Hz (Factory set). It shall be suitable for load rating of 10 Amps.
- Controller shall be provided with terminal block to connect incoming power, variable outgoing power, and for interlock to blower motor and to safety device such as high ozone cut out switch. The Controller shall be provided with receptacle to accept easy plug in cable connector, for communication to Sensor. Controller shall be provided with 3 Lamps to indicate Power On Automatic, Manual Bypass.
- Controller shall be provided with rocker switch to choose Automatic or Manual Mode of operation. In the Manual Bypass Mode, voltage output of the Controller shall be 100% of input voltage, regardless of the level of VOC.
- Cable connector between Controller and Sensor, length not less than 7.5 M (25ft) shall be factory provided (specify length if longer than 25 feet is required). This shall be complete with cables to provide power to Sensor and transfer signals for the different levels of VOC from Sensor to Controller.

12. DRY SCRUBBER**12.1 SCOPE**

The Dry scrubber unit shall be UL/CE certified and of the type as indicated on Drawings and identified in Schedule of Quantities.

12.2 TYPE

The unit shall provide efficiency of 90% or better for single pass based on ASHRAE test method at flow rates of 800 – 1300 CFM per module (supported by sample test report by a US laboratory). Multiple units can be joined together for increased volume. The system shall be suitable to connect to fan section with average velocity of not exceeding 500 FPM across air cleaner. (Or as indicated in the BOQ)

The unit shall be designed and constructed and supplied by a manufacturer specializing in the research, design and manufacture of products specified in this section with a minimum of three years of documented experience, and capable of issuing complete catalogue data on the total product.

12.3 UNIT HOUSING

- Housing shall be 16-gauge zinc coated GSS/Cold-rolled steel sheet with powder coating construction to protect against rust and corrosion. Each section shall include single door access, located one side of the unit. The access door shall be mounted on steel hinges and secured with adjustable, gasket sealed lever latches allowing for component access and removal. All doors shall be gasketed to prevent air and water leakage. Doors to charged high voltage components shall be equipped with electrical interlocks, for interconnection into the primary power supply, to prevent access when the components are energized. The housing shall be furnished completely assembled for ease of shipment and installation. Between each section, a permanent 1/8" thick gasket shall be installed to prevent leakage. The bottom drain pans under ESP section containing integral washing systems shall be pitched downward 1/4" per foot minimum toward a 3" NPT drain nipple.
- The sections are to be mounted on a structural C-channel or floor mounting or ceiling suspension. Lifting lugs shall be incorporated in the base channel to allow for rigging, if ordered.
- The external casing finish shall be a durable industrial grade semi gloss baked-on epoxy ester, not less than 3 mil minimum thicknesses.

12.4 CELL WASH MODULE

The Cells Wash module shall incorporate mechanical filtration. The stationary filter from the direction of airflow will be a metal mesh filters with single, gasketed access doors. Wash manifolds and headers are supplied to wash the module during the normal wash cycle.

12.5 ELECTROSTATIC PRICIPITATOR MODULE

The electronic air cleaner shall be the two-stage dual voltage plate type cells, rated at not less than 90% efficiency as per the ASHRAE test standards for dry particulate (supported by sample test report by a reputed laboratory for the make and model supplied for this project). The collection cells shall be in Single Pass arrangement to provide for maximum collection efficiency. The system shall be suitable to connect to fan section with average velocity of not exceeding 500 FPM across air cleaner.

12.6 IONISING COLLECTION CELL

Ionizing-Collecting cell(s) shall be of one-piece construction 14.23" inches deep in direction of airflow. All support framing, end plates and ionizer ground electrodes shall be 0.090-inch-thick aluminium. Both repelling and collector plates shall be 0.020-inch-thick aluminium, 9.125 inch deep in direction of airflow and rigidly retained in place with tubular spacers and tie rods. Spacing between plates shall be no less than 0.175 inch. Ionizing electrodes shall be 24-gauge stainless steel spiked design, ionization wires are not acceptable, rigidly supported both vertically and laterally. High voltage support insulators shall be of self-glazing Cordierite ceramic with all surfaces, including centre hole, glazed to enhance dielectric strength and retard tracking. Insulators shall be mounted out of the airstream, to reduce contaminant build-up. All high voltage electrical connections within each tier of cells, shall be between cells and automatically made when cells are installed. All electrical connections between unit tiers and high voltage connections between power packs and cells shall be located on the access door end of the cabinet and manually connected for ease of service.

12.7 POWER SUPPLIES

Power supplies shall be 100% solid state, UL Listed. operate on 200 to 240 VAC, 50 HZ, 1 Phase input and provide a dual high voltage output of (+) 12 to 13 KVDC for the ionizer and (+) 6.0 to 6.5 KVDC for the collector. A regulated output of up to 2.7 to 5.5 MA shall be supplied to maintain the specified collection efficiency. Integrally mounted electrical interlocks

shall be provided to prevent access to the high voltage components without first interrupting the primary input power. The power supply shall operate over a temperature range of -10°C /14°F to 60°C /140 °F, be self-protecting and accommodate an LED light indicating the performance status of the ionizing/collecting cell. High voltage output leads shall be sealed, and a bleed resistor incorporated to remove stored electrical charge where the power supply(s) are de-energized. Module of capacity above 3000 CFM shall be equipped with Pulse width modulating (PWM) to maintain the specified collection efficiency by maintaining a constant charge in the event of Low/High Voltage from source thus ensuring that the unit functionality is not affected with these voltage fluctuations. Power Consumption should not be more than 50 watts per ESP cell.

12.8 SYSTEM CONTROLS

- Programmable Logic Controller (PLC) shall be housed in a NEMA-12 type enclosure. Controller shall be shipped for remote mounting and must be installed indoors, or other means of weather protection provided if installed. Terminals shall be provided to interconnect the system fan and shall sequence the detergent wash, soak, rinse fan force dry and return to operation cycle. All sequence times shall be factory set. Control initiation shall be semiautomatic, push button initiated, or fully automatic by time clock, with semiautomatic push button override.
- A remote mounted Sleep Mode Reset Switch (momentary contact push button type) shall be supplied to be installed at the kitchen hood location to re-energize the air cleaning system after the wash system has completed. The switch may optionally be installed on the panel of the ATS control enclosure.
- The control cabinet shall be furnished with a factory installed and wired 7-day initiator clock with battery backup.

12.9 WATER /DETERGENT WASH SYSTEM

AUTO Detergent wash and rinse will be accomplished with manifolds located on the air entering sides of the (pre-filter wash collar if supplied) ionizing/collecting cell tier through spray nozzles delivering a cone shaped pattern. The detergent reservoir, pump, motor and bypass valve shall be provided as a pre-packaged assembly with an adjustable detergent volume setting. The detergent pump motor shall be 0.75kW TEFV motor, 220v/50hz/1ph, with pump of positive displacement self priming and deliver not less than 6 GPM at 50 PSIG minimum outlet pressure. Pump motor shall contain built-in overload protection. Main water line

strainer and solenoid valves are to be factory furnished with the system. Detergent system shall be of suitable capacity tank for remote mounting with initial supply of biodegradable detergent as per unit manufacturer's recommendations.

12.10 STATIC PRESSURE DROPS

- The pressure drop shall not exceed the following (inches H₂O):
 - ESP Section 0.14"
 - Metal Mesh prefilter or after filter 0.10"
- The ESP section must have both an internal pre-filter and an after filter, select and add for each.
- External losses for ductwork, exhaust hoods, manufacturing equipment with associated entry losses, kitchen hoods, etc. must be added with the above internal equipment losses to calculate total fan static pressure required.

12.11 ABSORBER MODULE

The Absorber Module shall be designed to utilize optimum number of trays that are powder painted for corrosion resistance, may be reused, and are secured in a V-bank arrangement on steel slide tracks. Trays shall be charged with minimum 15 lbs. of activated carbon granules.

13. PIPES AND FITTINGS**13.1 SCOPE**

The scope of this section comprises the supply and laying of pipes, pipe fittings and valves, testing and balancing of brine / chilled water piping required for the complete installation as shown on the Drawings. All piping inclusive of fittings and valves shall follow the Indian Standards.

13.2 PIPE SIZES

Pipe sizes shall be as required for the individual fluid flows. Various pipe sizes have been indicated on the Drawings, these are for Tenderer's guidance only and shall not relieve tenderer of responsibility for providing smooth noiseless balanced circulation of fluids.

13.3 PIPING

- The pipes and fittings shall be Mild Steel (MS) Class 'C' (Heavy Class) conforming to IS:1239 Code for pipes upto 150mm dia. Factory rolled pipes 150mm dia & above shall conforming to IS:3589. The Pipes of sizes 150mm & below shall be M.S. 'C' class as per IS : 1239 and pipes size above 150mm shall be welded black steel pipe heavy class as per IS: 3589, from minimum 6.35mm thick M.S. Sheet for pipes upto 350 mm dia. and from minimum 7mm thick MS sheet for pipes of 400 mm dia and above. All jointing in the pipe system shall generally be by welding, unless otherwise mentioned, or directed at site. All welding shall be done by qualified welders and shall strictly conform to IS Code of practice for manual metal arc, welding of Mild Steel.
- All welded joints (except pipe welded end-to-end) shall be made by use of forged one-piece welding flanges, caps, nozzles, elbows, branch outlets and tees of approved make. For pipes upto 200mm diameter, readymade pipe fittings shall be used. Fabricated fitting shall not be used for pipes upto 200mm. Cut samples shall be submitted for approval, if directed. All such fittings etc. shall be of a type which maintain full wall-thickness at all points, simple radius and fillets, and proper bevels or shoulders at ends. All job welding shall be done by the electric arc welding process in accordance with the following :
- All joints shall have 45 degree bevel type, pipe mill-bevelled or machine-bevelled
- All scale & oxide shall be removed with hammer, chisel/file & bevel left smooth and clean.

- Pipe lengths shall line up straight with abutting pipe ends concentric.
- Both conductors from the welding machine shall be extended to locations at which welding work is being done. The leads from welding machine to location of welding work shall be held together with tape or other approved means so as to prevent induced current in structural steel, in piping or in other metals within the building. The ground lead shall be connected to length of pipe through joints in pipe, structural steel of building or steel pipe supports.
- All pipes and their steel supports shall be thoroughly cleaned and given one primary coat of red oxide paint before being installed. For vibration isolators pre-moulded polyurethane pipe sections of 160 Kg/m³ density with adhesive shall be fixed between pipe and MS support. 10 mm thick MS 'U' clamp shall be fixed on the pipe so that the pipe is kept in position. All welded piping shall be subject to the approval at site.
- Fittings shall be malleable casting of pressure rating suitable for the piping system. Fittings used on welded piping shall be of the weldable type. These shall form part of piping and are not separately identified in Bill of Quantities.
- Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.

13.4 PIPE INSULATION

- The Insulation shall be closed cell nitrile rubber Class O with a density of 40-55 kg/m³ and a thermal conductivity of 0.038 W/m-K at 20 deg C
- The outer surface of the pipes on which the insulation is to be provided shall be thoroughly cleaned and rendered free from all dust and grease. All MS pipes shall be provided with a coat of zinc chromate/bituminous primer. As per LEED Requirement all paints used in the HVAC works must also be low VOC with the allowable VOC content for flat paints being 50 grams/liter, for non-flat paints being 150 grams/liter and for anti-corrosive paints being 250 grams/liter.
- Good quality adhesive as per manufacturer recommendation should be used for pasting 100% surface area of insulation to the pipe surface without leaving any air bubble or sag between two surfaces. The joints shall be paste along the thickness of the insulating material.

- All the adhesives used in the HVAC works must be low-VOC and the maximum VOC content for fiberglass adhesives cannot exceed 50 grams/liter and for sheet applied rubber insulation cannot exceed 850 grams/liter.
- The insulation material shall be closed cell nitrile rubber shall be in sleeve form for pipe size up to 80mm. These sleeves shall be factory cut and self-adhesive type. For bigger sizes, factory pre-cut sheet shall be used made for particular pipe sizes. The thickness of insulation shall be as identified in the schedule of quantity. The insulation joints shall be butted tightly.
- Insulation for union and expansion joints shall be built up type with a slab and the insulation shall extend 12 mm beyond the adjoining insulation for identifications. The ends of piping insulation shall be sealed with glass cloth.
- All insulated pipes shall be labelled (S, R or RR) and provided with 300 mm wide band of paint along the circumference at every 1200 mm distance for colour coding. Direction of fluid shall also be marked.
- All valves, fittings, strainers etc. shall be insulated to the same thickness and in the same manner as for the respective piping, taking care to allow operation of valves without damaging the insulation.
- All Piping Insulation upto 32mm shall be single layered and shall be protected as per BOQ Specifications

Codes and Standards

IS 1239	:	MS ERW Class C [upto 150 mm dia]
IS 3589	:	MS ERW [above 150 mm]
ASTM A53 Gr.B	:	Carbon steel pipes
ASTM C 518	:	Insulation thermal conductivity, 'K' factor

13.5 UV Protection.

Exposed insulated pipes are prone to heavy weathering, They must be withstand summer , monsoon and winter, Providing UV Protection enhances its life manifold, UV coating must be done by a compound which is a specially formulated water based coating suitable for

protection of flexible thermal insulation materials against sunlight. To increase its resistance coating can be further strengthened by sandwiching a glass fiber mesh between two coats of rubber adhesive over insulated pipes.

13.6 BUTTERFLY VALVES

Butterfly valves shall be of slim seal, short wafer type with standard finish. The valves shall be suitable for mounting between flanges drilled to ANSI 125. The valve body shall be cast iron and the disc shall be of cast iron or ductile iron. The disc shall consist of disc pivot and driving stem. The disc shall move in bearings on both ends with 'O' Ring to prevent leakage. The seat shall be moulded black nitrile rubber or EPDM. The valves shall be suitable for a working pressure of 16.5 kg/scm and shall be complete with flow control lever and notches, factory machined companion flanges, bolts & nuts. Valves above 200 mm dia shall be gear driven.

13.7 FLOW CONTROL VALVES - PRESSURE INDEPENDENT DYNAMIC CONTROL VALVE

- Supply, Installation, testing and commissioning of Pressure independent type 2 way Balancing and modulating Control valves in a single Unit of Valve. (PN-10)10 Kg. per sq.cm gauge working pressure. It should be diaphragm type & pressure balancing should be done with Delta P controller only (not cartridge). Pressure Drop across the valve must not exceed 35 kpa .Valve authority should be 100%.
- DN 15 to DN 32 Brass Body Ext. Threaded DN 40 & DN 50 Cast Iron Body, Ext. Threaded
- DN 65 to DN 100 Cast Iron body, Flanged Ends Connection
- Duly mounted with Modulating actuator IP42/54 Accordingly type suitable for 24V AC. Actuator should be Gear type only (not thermal/wax) & should have the self-calibrating feature. Valve &
- Actuator combination should be able to give logarithmic control characteristics to achieve linear control.
- The Valve should be selected to enable lowest possible pressure drop to have benefits of lower recurring Pumping Energy.

- Delta p controller should ensure 100% valve authority on all part loads. Actuator shall be able to work against maximum closing pressure of 6 bars.
- Measuring nipples should be provided to measure / verify actual pressure drop on site. This helps in optimization of Pump head.
- PIBCV Valve and cooling coil combination should be of linear control characteristics.
- Valve shall be electronic, dynamic, modulating, 2-way, control device.
- Dynamic control valve shall accurately control flow, independent of system pressure fluctuation.
- All PIBCV valves shall be manufactured in accordance ISO 9001 and ISO 14001. Certificate of Origin and Certificate of Quality from factory shall be submitted for inspection when the valves are delivered to site before installation.
- Leakage rate shall be class IV 0.01% for DN15 to DN150

ACTUATOR SPECIFICATIONS FOR ALL SIZES

- Supply Voltage : 22-26V AC /24-230 V AC
- Power Consumption : 10V AC
- Frequency : 50/60 HZ
- Control Input : 2-10V DC, 0-10 VDC, 4-20mA, 3-point floating, ON/OFF
- Position Output : 2-10V DC 4-20mA
- Housing Insulation : IP 44/54
- Valve actuator housing shall be rated to IP 20.
- Actuator shall be driven by a 22-26V AC or 28-32V DC motor, and shall accept 2-10 VDC, 0-10 VDC,
- 4-20 MA, 3-point floating or ON/OFF electric signal and shall include resistor to facilitate any of these signals.

13.8 BALL VALVES

The ball valve shall be made forged bronze. The valve shall be internally threaded to receive pipe connections upto 40NB dia. The ball shall be made from stainless steel and machined to perfect round shape and subsequently chrome plated. The seat of the valve body-bonnet gasket and gland packing shall be of Teflon. The handle shall be provided with PVC jacket. The handle shall also indicate the direction of 'open' and 'closed' situations. The gap between the ball and the Teflon packing shall be sealed to prevent water seeping. The handle shall also be provided with a lug to keep the movement of the ball valve within 90°. The lever shall be operated smoothly and without application of any unnecessary force.

13.9 BALANCING VALVES

Balancing Valves shall be provided at Chiller, Condenser, Heat Pump, Cooling Tower and each AHU outlet line as indicated in drawing. These valves shall have built in pressure drop measuring facility to compute flow rate across the valve. The test cocks shall be long enough to protrude out of pipe insulation. To measuring flow rate, differential pressure will be measured with calibrated instruments Digital or Mercury Manometer. Balancing Tools shall have a programme to provide the following functions:

To balance the HVAC installation and calculate the necessary valve settings based on the systems data as observed prior to balancing exercise.

- To log measured values from a valve (differential pressure and flow rate)
- To store the results of balancing
- To printout saved data in computerized measurement protocol (CMP) consisting of:
 - Name and Size of Balancing Valves
 - Presetting position of Balancing Valves
 - Design Flow for each Balancing Valves
 - Flow at Balancing Valves
 - Flow Ratio pre-balancing based on actual flow / design flow

- Flow Ratio post-balancing and Actual Flow

The balancing valves of size 25mm to 50mm dia shall be of Gun Metal Construction with screwed ends. Whereas Valves of size 65mm to 300mm shall be of Cast Iron to IS 210 Gr. FG 260 Flanged

Construction.

The detailed material of construction shall be as given below -

- Balancing Valves 25mm to 50mm (Gun Metal Screwed End Construction)
- Pressure Rating: PN-10
- Style : Globe Type BSP Threaded Screwed End Construction
- Body Test Pr. :16 Bar (g)
- Material of Construction
- Body : IS 318 LTB 2 (Gun Metal)
- Bonnet : 25mm in brass and 32 mm to 50mm in IS 318 LTB 2 (Gun Metal)
- Plug : IS 318 LTB 2 (Gun Metal) / Brass IS 319
- Stem : IS 319 Type-I (Brass)
- Temperature : -46 Deg C to + 200 Deg C
- Gland Nut : Brass
- Hand Wheel : Nylon Gr. 66
- Pressure Test Cocks : Brass
- Balancing Valves 65 mm to 300mm (Cast Iron Flanged End Construction)
- Pressure Rating : PN-10
- Style : Globe Type Flanged End Construction
- Body Test Pr. : 16 Bar (g)

- Material of Construction
- Body : Cast Iron to IS 210 Gr. FG 260
- Bonnet : Cast Iron to IS 210 Gr. FG 260
- Hand Wheel : M S Fabricated
- Stem : SS-410
- Disc : SS-410 / EN-3
- Sealing Disc : E P D M
- Temp Range : -40 Deg. C to +120 Deg. C
- Pressure Test Cocks : Steel Chrome Plated
- End Connection : IS: 6392 Table 17

All valves shall be tested for flow vs. pressure drop within + 5% accuracy and data be furnished as part of Test Certificate.

Balancing of the Water System

- The Balancing of water system is to be done by a HVAC contractor with the help of a software package, digital differential pressure measuring instrument or Mercury Manometer.
- A balanced flow condition in a system is when the total flow is distributed amongst the terminal units
- (AHUs etc.) in equal proportion to the design flow so that a single point regulation from the supply point (Pumps etc) can correct the flow through all the terminal units still in balanced manner.

13.10 CHECK VALVES (NRV)

Check Valve shall be of High Grade Cast Iron epoxy coated, suitable for PN 16 bar service as specified. The valve shall be of dual plate wafer design suitable to mount between the flanges. The disc shall be of stainless steel grade SS 304. The spring shall be of Stainless Steel. The Seal shall be of EPDM elastomer.

13.11 RUBBER BELLOWS

- i. The Expansion Bellows shall be flanged type expansion joint. Flanges shall be non-compressible and mechanically strong type and the Neoprene rubber shall be provided in between the flange ends. The Bellow shall work for a temperature range of minus 10°C to 70°C.

The length and working pressure of bellows shall be as follows:

Nominal Bore (mm)	Length (mm)	Pressure Rating
Upto 200	150	PN16
above 200	200	PN16

- ii. Bellows shall be provided with control roads to control the excessive elongation or compression of piping systems.
- iii. It shall have torsional movement up to 3° without damage.
- iv. Bellows shall be single arch.

13.12 STRAINERS

- Strainers shall be of cast iron body. Strainers shall incorporate a removable SS-316 screen with 3mm perforations and a permanent magnet. Strainers shall be provided with matching flanges at both ends for connecting brine / chilled water pipes. They shall be designed to enable blowing out the accumulated dirt and facilitate removal / replacement of screen without disconnecting the main pipe. The types of strainers are as specified in the BOQ.
- Suction Guides (SGs) shall be installed on the suction side of pumps to protect against damage from debris and foreign matter, and optimize flow efficiency. The Guide should be complete with flow stabilizing vanes on the outlet with removable stainless steel strainer having a free area of at least 250% of pipe sectional area. A disposable fine mesh strainer should be installed for startup cleaning.

Material of Construction

- Body: Cast Iron, Ductile inner carbon steel with DIN flingers.
- Strainers: 3 mm (1/8") perforated stainless steel star shaped.
- Suction guide with strainer shall be of cast Iron body, outlet guide vanes, removable SS Strainer to be provided at suction of each pump. Complete with Grooved flange Adapter 50 mm and above dia. All Pipe bends shall be prefabricated type upto 150mm dia. Pipe bends fabricated at site shall be provided with segments of bend not exceeding 150angle. A 90o bend shall thus be provided with 6 Nos. welding joints. Pipes shall be cut with Power saw/Hacksaw only, followed by hand grinding to provide V-groove. Pot strainers shall be fabricated out of MS sheet with bronze/SS 304 basket of sizes as under:

Pipe sizes (mm)	Pot dia (mm)	Pot Height (mm)	Basket dia (mm)	Basket Height (mm)
50	300	400	200	240
80	350	450	250	250
100	450	500	300	280
125	500	600	330	340
150	540	700	360	390
200	610	815	400	470
250	800	955	550	510
300	1000	1105	750	580
350	1190	1300	895	678
400	1350	1500	1020	785
450	1518	1700	1060	890
500	1690	1800	1100	900

- Pot strainer shall be fabricated out of MS plate up to 100mm dia pipes shall be fabricated of 6mm thick MS sheet, 125 to 300 mm dia pipes of 8mm thick and higher sizes above of 12mm thick. All strainers shall be sized to provide minimum resistance through perforated vessel & shall be sized as per given table.

13.13 FLANGES & UNIONS

Sufficient number of flanges and unions shall be provided as required to facilitate the maintenance work after the piping is installed. Mild steel ANSI 125 flanges shall be used for

pipes of 65mm dia and above. Flanges shall be of approved make. The supply of flanges shall form part of piping (not separately identified in Bill of Quantities) and shall also include supply of bolts, washers, nuts and suitable asbestos fibre / rubber insertion gaskets (min 3 mm thick).

All bends up to 65 mm NB shall be hydraulically formed with a minimum R/D of three unless space restrictions inhibit, in which case long radius elbows may be used with the approval of the Client. For sizes up to 50 mm NB, socket weld fittings shall be used. For larger sizes butt welding wrought steel fittings to BS 1965 and matching with the straight pipe wall thickness shall be used. **All elbows have to be long radius elbows considering pressure losses.**

- a) Flanges shall be carbon steel raised face conforming to IS: 6392. or ASTM Standard as per Valve Pitch Circular Diameters
- b) Pressure rating shall be:

Minimum: PN10 (BS. EN:1092)

Maximum: PN16, 20, 25, 40
- c) According to the system pressure. System pressure shall be reckoned as 1.25 times the maximum pressure recorded on a pressure gauge mounted immediately after the pump discharge. (Pump no-delivery head + the static head of the standing column of water). All components like flanges, fittings, valves, vents, strainers etc. shall be rated for the system pressure.
- d) Flange gaskets shall be as follows:

Up to PN10 3 mm reinforced Teflon at ring

Over PN10 3 to 6mm serrated or laminated gasket.
- e) Pressure on the gaskets shall be applied uniformly through a torque – wrench for achieving uniform pressure and a leak-tight joint.

13.14 PRESSURE GAUGES AND THERMOMETERS

- Both pressure gauge and Thermometer shall be made of stainless steel body and stem. The gauges shall be weather proof and water proof. The valve shall have the accuracy of +/- 1% of the reading

- Pressure gauges shall be not less than 150 mm dia. They shall be selected for appropriate range and shall be complete with siphon and cock, etc. Pressure gages as specified shall be provided at brine / chilled water supply and return at each air handling units shown on the Drawings and included in Bill of Quantities. Care shall be taken to protect pressure gauges during testing. Pressure gage sockets on insulated pipes and accessories shall be extended upto insulation to avoid damage of insulation for replacement of gauges.
- Thermometers shall be of stainless-steel construction with dial of 150mm dia and range up to 50°C, with 0.5°C least count and shall be calibrated before installation.
- The thermometers shall be installed in separate brass oil wells of 1/2" size with a stem of minimum 3/4th of pipe. Thermometers for insulated piping shall be installed in extended neck to avoid damage or deformation of the insulation.

13.15 AIR & DIRT SEPARATORS

- Microbubble type Air Separator based on the concept of Coalescence where bubbles tend to adhere and then grow to form larger and rise higher.
- The separator shall have stainless steel pall rings to increase the surface area and probability of collision of air bubbles.
- Air separator shall be designed and fabricated out of carbon steel as per ASME VIII Div.1/ASME B31.3. The Separator shall be designed for a pressure of PN16. The Air Separator shall have high-capacity bronze auto air vents.
- The Height of the legs shall be suit to site to avoid unnecessary bends.
- The Air separator shall be Insulated as mentioned in piping specifications.
- The Air separator shall be magnetic and remove ferrous particles less than 5 micron.
- For isolation of small-bore pipework tapings for instrumentation equipment etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valve with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or near surface.

13.16 CLOSED EXPANSION TANK

- The closed expansion tank (PN16) will be of Mild Steel construction with interchangeable EPDM-BUTYL rubber membrane. The expansion tank shall be complete with safety relief

valve, pressure reducing valve and pressure gauge. The quoted price shall be inclusive of structural support for the tank.

- The tank will be of pressure rating to suit the system pressure and will be sized to adequately compensate for water expansion due to operating temperature variations. The tank shall be fabricated as per IS 2825 for “non-fired pressure vessels” and the flanges shall be as per IS 6392.
- For chilled water application, it will be insulated as per BOQ
- The expansion tank shall be supplied along with pressurization unit. The pressurization unit shall consist of two nos. (1 working + 1 stand-by) high pressure pumps of suitable pressure rating mounted on M.S. frame, complete with interconnecting piping, isolation valves, NRV, Y-strainer, pressure gauge, pressure transmitter, auto-logic panel (IP 55) with dry-run protection, electrical MCB and interconnecting wiring. The unit shall be housed in powder-painted canopy suitable for external installation, if required.

13.17 AUTOMATIC AIR VENTS

The float shall be of synthetic material and shall keep the venting valve closed under normal condition. When air is collected inside the float chamber, the water level inside the auto air vent shall decrease and the venting valve shall be opened. The collected air then shall escape through the venting valve and the water level inside the float chamber shall increase again, closing the venting valve. This process shall continue as long as air is collected in the float chamber. There shall be a check valve at the bottom to seal the system when the auto air vent is removed for servicing.

13.18 PIPING INSTALLATION

- All pipes support shall be mild steel, thoroughly cleaned and given one primary coat of red oxide paint before being installed. No pipes can be supported from deck slabs. All supports shall be welded / bolted on a MS Plate which itself shall be welded to the primary / secondary beams. Contractor to refer the typical supporting arrangement drawing for better clarity.
- The installation work shall be carried out in accordance with the detailed approved drawings prepared by the Air-conditioning Contractor
- Air-conditioning contractor shall utilize the structural provisions for Air-conditioning services wherever provided by the Department in the building and make his own arrangements for additional changes.

- Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.
- Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely, in other locations, concentric reducers may be used.
- Open ends of piping shall be blocked as soon as the pipe is installed to avoid entrance of foreign matter.
- All pipes using screwed fittings shall be accurately cut to the required size and threaded in accordance with IS: 554 and burs removed before laying.
- Piping installation shall be supported on or suspended from the structure (Beams only) adequately. The Air-conditioning contractor shall design all brackets, saddles, clamps, hangers etc. and shall be responsible for their structure integrity.
- Pipe supports, preferably floor mounted shall be of steel, adjustable for height and prime-coated with zinc chromate paint and finish-coated Gray. Spacing of pipe supports shall not be more than that specified below: -

Nominal Pipe size (mm)	Spacing (Metres)
12 and 15	1.25
20 and 25	2.00
32, 40, 50 and 65	2.50
80, 100 and 125	2.50
150 and above	3.00

- Extra supports shall be provided at the bends and at heavy fittings like valves to avoid undue stress on the pipes.
- Extra supports shall be provided as per availability of beams as per site conditions.
- Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation.
- Anti-vibration pads, springs or liners of resilient and non-deteriorating, material shall be provided at each support, so as to prevent transmission of vibration through the supports.
- Pipe sleeves of diameter larger than the pipe by least 50 mm shall be provided wherever pipes pass through walls and the annular spaces shall be filled with felt and finished with retaining rings.

- Vertical risers shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe with a 12 mm thick rubber pad or any other resilient material
- The space in the floor cut outs around the pipe work (after insulation work where applicable) shall be closed using cement concrete (1:2:4 mix) or steel sheet, from the fire safety considerations, taking care to see that a small annular space is left around the pipes to prevent transmission of vibration to the structure.
- Riser shall have suitable supports at the lowest point.
- All pipes and their steel supports shall be thoroughly cleaned and given one primer coat of Zinc chromate before being installed.
- After all the water piping has been installed, pressure tested, all exposed piping in the plant room shall be given two finish coats of paint, as per approvals. Similar painting work shall be done over insulated pipe work, valves etc. The direction of flow of fluid in the pipes shall be indicated with identifying arrows stickers.
- mm gasket shall be used for flanged joints.
- Cut-outs in floor slabs shall be sealed with cement concrete or fire sealant after the plumbing work is done, from the fire safety point of view.
- The Tenderer shall make sure that the clamps, brackets, clamp saddles and hangers provided for pipe supports are adequate. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.
- All pipes shall be accurately cut to the required size in accordance with relevant BIS Codes, edges bevelled and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reducers shall be used for the piping to drain freely. In other locations, concentric reducers may be used.
- Flanged inspection pieces 1.5 meters long, with bolted flanges on both ends, shall be provided no more than 30 meters centres, or where-ever shown in Approved-for-Construction shop drawings, to facilitate future cleaning of all welded pipes.
Auto purge valves shall be provided at all highest points in the piping system for venting air.
Air valves shall be 15 mm pipe size with screwed joints
- Discharge from the air valves shall be piped through an equal sized mild steel or galvanized steel pipe to the nearest drain or sump. These pipes shall be pitched towards drain points.

- All piping and fittings shall be pressure tested, painted and then insulated as described under the section "Insulation".
- All pipes supports shall have vibration isolation arrangement.
- Necessary sockets and nipples with suitable brass thermo well for mounting sensors / transmitters on pipe line to interface the BMS system.

13.19 TESTING

- During construction, the tenderer shall properly cap all lines, so as to prevent the entrance of sand, dirt, etc. Each system of piping shall be flushed thoroughly after completion (for the purpose of removing dirt, grit, sand etc. from the piping and fittings) for as long a time as is required to thoroughly clean the system.
- All piping shall be tested to hydrostatic test pressure of atleast two and half times the maximum operating pressure, but not less than 10 kg/sq.cm gage for a period of not less than 48 hours. All leaks and defects in joints revealed during the testing shall be rectified, retested and gotten approved.
- Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.
- Piping may be tested in sections and such sections shall be securely capped, then re-tested for the entire system.
- The Tenderer shall give sufficient notice to all other agencies at site, of his intention to test a section or sections of piping and all testing shall be witnessed and recorded by Client / Consultant's site representative.
- The tenderers shall provide temporary pipe connections to initially by-pass condenser / chiller and circulate water through condenser/chilled water pipe lines for min 8 hours. Water should be drained out from the lowest point. The temporary lines shall be removed and blanked with dead flanges. Pot strainers and Y strainers shall be cleaned and fresh water filled in the circuits.
- The Tenderer shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. If proper circulation is not achieved due to air bound connection, the Tenderer shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications including the tearing up and re-finishing of floors and walls if required.
- After the piping has been installed, tested and run for atleast three days of eight hours each, all insulated exposed piping in plant room shall be given two finish coats, 3 mils each of approved colour, conforming to relevant BIS Codes. The direction of flow of fluid in the pipes

shall be visibly marked with identifying arrows. For painting of insulated and clad pipes refer to Insulation section.

- After testing, all systems shall be chemically cleaned. After cleaning, the pipe work should be rinsed multiples times until the system is neutral.
- Before handover Client / Architect / Consultant's representative shall be provided with certificate of cleaning of pipe systems, signed by the Tenderer.
- The Tenderer shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and after testing.

13.20 BALANCING

- After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted, or as directed.
- All balancing valves, Automatic control valves and two-way diverting valves shall be set for full flow condition during balancing procedure. Each water circuit shall be adjusted thru balancing valves provided for this purpose; these shall be permanently marked after balancing is completed, so that they can be restored to their correct positions, if disturbed.
- Complete certified balancing report shall be submitted for evaluation and approval by Client / Consultant's site representative. Upon approval, four copies of the balancing report shall be submitted with the as-installed drawings and completion documents.

13.21 VALVE IDENTIFICATION

- Provide 30 mm dia brass valve tag, with embossed letters and number for each valve and attach the tag to valve handle by "S" hook or by suitable means. Tenderer shall provide valve tag schedule and valve chart for each piping system, consisting of schematic drawing of piping layout, along with a valve list, showing and identifying each valve by number, service and location and describing its function.
- The tenderer shall frame under glass in the air-conditioning plant room or as directed by Client / Architect / Consultant's representative two copies of valve chart. Two additional uncounted copies shall be supplied to the Client / Consultant's site representative. Tags shall correspond with the valve schedule and record drawings. In back of house areas, where ceilings are installed and the valve or valve tag is not visible, a self-adhering tag with the valve number shall be installed on the wall or directly under the ceiling. For public area ceiling valves, these tags are to be installed in the service corridor, leading to the public areas.

13.22 BTUH METERS WITH MATCH PAIR SENSORS**EQUIPMENT SPECIFICATIONS FOR BTUH METERS WITH MATCH PAIR SENSORS****13.22.1 BTU Meter Specification:**

ULTRASONIC BTU METERS cooling meter, PT500 2-wire with integrated ultrasonic flow sensor with 2.5 m signal cable incl. power supply option of 13 Years Battery Backup or 230v AC, a set of short direct or pocket sensors with 1.5 m cable and 2 nipples or 2 stainless steel pockets (65 or 90 mm/140mm). Both Ultrasonic Flow Part & Calculator should be from Same company only. All meters should be Flange Connection only.

13.22.2 Flow / Dia Selection:

When dimensioning meter, two major conditions must be stated: pipe dimension and maximum flow of the system. Regarding pipe dimension, going one dimension up or down in meter size will in general cause no problems, as long as the second parameter, the maximum flow does not exceed the nominal flow of the flow meter. Maximum flow of the system must be obtained without exceeding the nominal flow.

13.22.3 Approved meter data

- EU-directives
 - MID (Measuring Instruments Directive)
 - LVD (Low Voltage Directive)
 - EMC (Electro Magnetic / Ultrasonic Compatibility Directive)
- Cooling meter
 - Temperature range: 2°C...50°C
- EN 1434 designation Environmental class A and C
- MID designation
 - Mechanical environment Class M1

- Electromagnetic environment Class E1 and E2

13.22.4 Calculator data

Typical accuracy

Calculator Ec $\square(0.15 + 2/\Delta\square)\%$

Sensor set Et $\square(0.4 + 4/\Delta\square)\%$

Display LCD – 7 (8) digits with a digit height of 7.6 mm

Resolution 9999.999 – 99999.99 – 999999.9 – 9999999

Energy units MWh – kWh – GJ – Gcal

13.22.5 Data logger (Eeprom)

- Standard 1392 hours, 460 days, 36 months, 15 years, 50 info codes
- Option Data loggers with programmable interval
- Clock/calendar Clock, calendar, leap-year compensation, target date, Real time clock with battery back-up.
- Data communication KMP protocol with CRC16 used for optical communication and for top and base modules.

13.22.6 Mains supply

230 VAC +15/-30%, 50/60 Hz

D-Cell	Battery	-13	Years

13.22.7 Battery Life: When used with Tenant Billing System/BMS, if the data is retrieved from BTU meter, following conditions shall apply

- Hourly Data Retrieval-9 Years
- Monthly- 12 Years

Communication: Modbus RS 485 / Bacnet IP

1. Complete chiller package including compressor, motor, drive, evaporator and condenser.
2. Refrigerant piping.
3. Charge of refrigerant and oil.
4. Controls and control panel.
5. Chilled water / Chilled Brine connections.
6. Condenser water connections.
7. Auxiliary water connections.
8. Purge unit.
9. Motor control panel including disconnect and starters.
10. Electrical power connections.
11. Isolators.

14. AIR DISTRIBUTION SYSTEM**14.1 SCOPE**

Supply, Fabrication, Installation, Testing and Commissioning of Sheet Metal Ducts, Supply, Installation, Testing and Balancing of Grilles and Diffusers, in accordance with these specifications and the General Arrangement shown on the Tender Drawings. The air distribution system shall be designed to convey correct quantities of conditioned air to provide the design air flow rate and environmental condition, while maintaining suitable area pressurization requirement within the conditioned space.

14.2 DUCT MATERIALS & SIZES**14.2.1 SCOPE**

The scope of work covers supply, installation, testing, adjusting, balancing, and commissioning of:

- Sheet metal ducting
- Volume, Smoke and Fire dampers
- Outside intakes & exhausts louvers
- All other accessories
- Associated with air-conditioning ventilation and exhaust systems meeting the intents of specifications & drawings.
- Kitchen Exhaust systems shall be as per BOQ

14.2.2 STANDARDS

All duct work shall conform generally to the following standards & codes.

IS:277	Galvanized sheet steel
IS:655	Air duct – Specification
IS:1079	Hot rolled carbon steel sheets
IS:513	Cold reduced low carbon steel sheet

Bureau of Indian Standards	National Building Code of India - 2016
SMACNA	Sheet Metal Contractors National Association
AMCA	Air Movement and Control Association
ASHRAE, Standards & Handbooks	The American Society of Heating, Refrigerating and Air- Conditioning Engineers
ANSI	The American National Standards Institute
ISHRAE	The Indian Society of Heating, Refrigerating and Air Conditioning Engineers
AHRI	The Air-Conditioning, Heating, and Refrigeration Institute
UL standards	Underwriters Laboratories Standards
NFPA 90A	Standard for the Installation of Air-Conditioning and Ventilating Systems
NFPA 90B	Standard for the Installation of Warm Air Heating and Air- Conditioning Systems
NFPA 92	Standard for Smoke Control Systems
NFPA 92A	Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences
NFPA 96	Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
Note - All codes and standards mean the latest.	

14.2.3 SUBMITTALS

- The contractors should submit shop drawings of all duct systems, equipment & air distribution system after a thorough survey of the space, obstructions, and other services elements. The shop drawings should indicate the following information:
- Source of manufacture and place
- Pressure class of ducting
- Bills of materials showing the duct areas in sq. meters for each system under each category of sheet thickness.

14.2.4 MATERIAL

- All ducts shall be fabricated either from Galvanised Sheet Steel (GSS) conforming to IS: 277. The steel sheets shall be hot dip galvanized with MAT finish with coating of minimum 120 grams per square meter (GSM) of Zinc, GI sheets shall be lead free, eco-friendly and RoHS compliant
- The thickness of sheets for fabrication of rectangular ductwork shall be as under. The thickness required corresponding to the longest side of the rectangular section shall be applicable for all the four sides of the ductwork. longest side (mm) Minimum sheet thickness.

Duct Longest Side Range	Thickness For GSS (mm)
750 mm and below	0.63
751 mm to 1500 mm	0.8
1501 mm to 2200 mm	1.00
2201 mm & above	1.25

14.2.5 SHEET METAL DUCT ACCESORIES

- Air turning devices shall be provided at least for first four outlet collars after every elbow and at all non-split branch take offs. Turning blades shall be fabricated out of 0.8 mm (22G) thick

G.S sheets and equally spaced on side runner to be riveted/bolted to duct sheets. All vanes shall be of double thickness.

- Splitter dampers shall be installed in branches wherever split takes place. Splitter dampers shall consist of double thickness air foil blades hinged at the downstream edge. The operation rod shall terminate outside of the duct and insulation, and an air tight hub and locking set screw shall be provided. Damper blade thickness shall be the same as the duct in which it is installed but not less than 1.5 mm. Entire splitter damper shall be enclosed in a sheet steel ducting with flanges at both ends aligning with main run of ducting. The enclosure shall be made of sheets one size larger than the upstream duct.

14.2.6 FLANGES & SUPPORTS

- Flanges for matching duct sections, stiffening angles (braces) and supporting angles shall be of rolled steel sections and shall be as per IS:655.
- Hanger rods shall be of mild steel and of at least 10 mm dia for ducts up to 2250 mm size, and 12 mm dia for larger sizes.
- All nuts, bolts and washers shall be zinc plated steel. All rivets shall be galvanised or shall be made of magnesium - aluminium alloy. Self-tapping screws shall not be used.

14.2.7 CONSTRUCTION

- Ducts shall be fabricated at site or factory fabricated and shall be generally as per IS: 655 "Specifications for metal air ducts", unless otherwise deviated in these General Specifications.
- The interior surfaces of the ducting shall be smooth.
- All the ducts up to 600 mm longest side shall be cross broken between flanges by a single continuous breaking. Ducts of size 600 mm and above shall be cross broken by single continuous breaking between flanges and bracings. Alternatively, beading at 300 mm centres for ducts up to 600 mm longest side, and 300 mm centres for ducts above 600 mm size shall be provided for stiffening. 99 shall be smooth finished for minimum frictional loss.

14.2.8 FIRE RATED DUCTWORK

- All the duct work for Smoke extraction system shall be provide with high-build Fire Retardant Coating for outside surface of the duct. The optimum thickness shall be achieved for fire paint for attaining a Fire Rating minimum of 2 hours.
- Same shall be tested at CBRI Roorkee to properties as per the requirements of BS 476: 6 & 7, including non-combustibility Class 0 and fire propagation Class 1 surface spread of flame & materials in accordance with Building Regulations.
- Fire rated painting is to be done at enclosed, dry, and properly ventilated space.
- First the factory / site fabricated duct piece shall be kept on the ground. The flange of the duct shall be ready with holes for nut bolting .
- Duct shall be thoroughly cleaned before start of the painting work to ensure no oil, dust , water & Rust to the surface.
- Apply Two coats of Fire-retardant solvent based base coat with minimum 250-micron layer per coat , in regular 4–6-hour Interval by Roller Brush/ Air less spray method without thinning of solvent.
- Let the base coat dry for min -6-8 Hours for normal shiny day.
- Then Apply 2-3 coats of fire-resistant water based Top coat in approximately 6-8 hours interval (depend upon weather conditions) As coat thickness shall be sufficient to achieve desired fire rating.
- Duct supports including nut bolt , washers also shall be cleaned and applied with fire paint as described above.
- First the supports shall be installed in place as per approved ducting layout followed by installation of fire painted ducts.
- Fire rated ducts shall be joined with fire rated nut bolts and fire rated gasket in between two pieces.

- After installation of duct work assembly in-place , if required finishing touch up of fire paint shall be applied where ever necessary .
- Entire duct assembly including supports shall be rated to withstand 250 deg C temperature for 2 hours.

14.2.9 LOUVERS

- Louvers complete with bird screen etc., shall be measured from the approved drawings / as built drawing on the basis of core area (excluding margin flanges) and paid per unit area. Louvers in supply and exhaust fan units are part of fan units and no separate payment will be made for the same. The louvers shall be made of extruded aluminium power coated, min. 2mm thick frame & min. 1.5mm thick fins within it.
- Any supports, nuts, bolts, anchors, fasteners, gasket, tools, gadgets etc. required for successful operation and acceptance shall be provided at no extra cost to the owner.
- A flanged frame using RS sections shall be provided on front face to conceal the gap between the louvers and the adjoining wall face. Corners of frame shall be welded. The frame shall be made structurally rigid.
- Louvers made from extruded aluminium section shall be in modular panel form for ease of handling. These shall be free from waves and buckles. Vertical blades shall be truly vertical and horizontal blades shall be truly horizontal. Butt joints in blades shall not be accepted.
- Additional intermediate equally spaced supports and stiffeners shall be provided to prevent sagging/vibrating of the louvers, at not more than 750mm centres where the louver's length is longer than 750mm.
- A bird wire screen made of 12 mm mesh in 1.6 mm steel wire held in angle or channel frame shall be fixed to the rear face of the louver frame by screens.
- Architect approvals for colour shades shall be taken before proceeding for procurement of the louvers

14.2.10 APPARATUS AND EQUIPMENT CONNECTIONS

- Equipment such as air handling units shall be connected to the duct by means of double canvas sleeve as per BOQ Specifications.
- Duct sleeves made of 20 SWG thick galvanized sheet shall be used for ducts passing through load bearing walls or partitions. Sleeves shall provide 25 mm clearance all around as per duct or insulated duct. The space between sleeve and duct shall be packed with twisted asbestos.
- All the sheet metal plenums required to confine the flow of air through filters and fans, shall be fabricated out of 18 SWG galvanized sheet steel, and suitably braced as required. Suitable access doors shall be provided for plenums.

14.2.11 JET NOZZLE

- Jet nozzles shall be suitable for installation on oval ducts. The discharge nozzle and face cover ring shall be made of aluminium, the mounting plate for the eyeball is aluminium or sheet steel, The duct connection element and duct connection pieces shall be of galvanised sheet steel. Jet nozzle, cover ring, eyeball, mounting plates shall be finish powder coated, resistant to saturate environment for minimum 100 hours without deterioration. Jet nozzle shall be available with rear mounted perforated sheet steel plate for flow rate control.
- Jet nozzles shall be suitable for long throw distances with optimum acoustic properties, preferably used for cooling in critical areas. Jet nozzles shall provide the adjustment facility manual or automatic using an electric actuator which allows variation in discharge angle to compensate for changing temperature differences, adjustment angular range 30° upwards to 30° downwards.
- Jet nozzle shall be selected for minimum pressure drop and sound level not exceeding 35NC, contractor shall submit the selection curves of product ratings from the manufacturer.

14.2.12 DIFFUSERS AND GRILLES (AIR DIFFUSION EQUIPMENT)

- The type and quantity of diffusers and grilles shall be provided, as specified in the drawing. The contractor shall ensure that the diffusers and grilles offered are of requisite capacity, throw and terminal velocity. Diffusers and grilles shall be fabricated extruded aluminium section with powder coating or SS 304, as specified in the BOQ

Whenever VCD is provided with diffusers or grilles it shall be located within the duct collar. Diffusers and grilles shall be of flush pattern.

- Ceiling diffuser shall be equipped with fixed air distribution grids, removable key operated volume control dampers and anti-smudge rings. The extruded aluminium or SS 304 diffusers shall be provided with removable central core and concealed key operation for volume control damper.
- Linear diffusers shall be of extruded aluminium or SS 304 construction.
- Slot diffuser shall be of extruded aluminium or SS 304 construction multi-slot type with air pattern controller provided in each slot. Supply air slot diffusers shall be provided with hit and miss VCDs in each slot.
- The outer framework of the grilles shall be made of not less than 1.6 mm thick aluminium sheet. The louvers shall be of aerofoil design of extruded aluminium section with minimum thickness of 0.8mm at front and shall be made of 0.8mm thick aluminium sheet. Louvers may be spaced 18 mm apart.
- The outer shell shall not be less than 1.6 mm thick extruded section aluminium sheet. The diffuser assembly shall not be less than 0.80 mm thick extruded aluminium section.
- Grilles with VCD shall be single acting or double acting, as specified in the drawing. Grilles without VCD shall have fixed blades or adjustable blades, as specified in the drawing.
- All diffusers, grilles and registers shall be of extruded aluminium construction, and epoxy powder coated
- Aluminium registers, diffusers and grilles shall be approved by Architect. Architect shall approve the shade of epoxy powder coating for grilles, registers and diffusers.
- Supply registers shall be of the rectangular universal type with adjustable horizontal and vertical vanes complete with opposed blade volume control dampers. Dampers shall be adjustable by a removable key or screwdriver from the face of the registers.
- Fresh air and discharge air grilles shall be of the fixed single louver type with opposed blade volume control dampers adjustable from the face of the grilles.
- The deflection of the grills shall be 0 degrees, 15 degrees based on the application.

- All diffusers, registers and grilles shall be selected to account for the noise levels as specified for various area.

14.2.13 SLOT DIFFUSERS

Slot diffuser shall be of extruded aluminium or SS 304 construction multi-slot type with air pattern controller provided in each slot. Supply air slot diffusers shall be provided with hit and miss / collar dampers VCDs in each slot.

14.2.14 MEASUREMENT

- a) All terminal devices shall be measured as per the face area of the duct being connected to the terminal i.e. neck sizes. No minimum criteria for measurement shall be accepted.
- b) The rates for the air terminal works shall include all wastage allowances, supports, hangers, nuts and check nuts, vibration isolators, suspension where specified or required, and any other item required to complete the installation. None of these items will be separately discussed, measured nor paid for.

14.3 DUCT CONSTRUCTION

- The duct shall be designed as per “equal friction method” as far as possible. All ducts shall be fabricated and installed in workmanlike manner, conforming to relevant SMACNA codes.
- Ducts so identified on the Drawings shall be acoustically lined and insulated from outside as indicated in Bill of Quantities. Duct dimensions shown on drawings, are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in Bill of quantities. The fabricated duct dimensions should be as per approved drawings and care should be taken to ensure that all connecting sections are dimensionally matched to avoid any gaps.
- Ducts shall be straight and smooth on the inside with longitudinal seams shall be airtight and at corners only which shall be either Pittsburgh or snap button as per SMACNA practice, to ensure air tightness.
- Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Air-turns (vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.

- Ducts shall be fabricated as per details shown on Drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles, of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.
- All sheet metal connection, partitions and plenums, required to confine the flow of air to and through the filters and fans, shall be constructed of 18 gauge GSS / 16gauge aluminum, thoroughly stiffened with 25mm x 25mm x 3mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Access doors shall be not less than 45cm x 45cm in size.
- Plenums shall be shop/factory fabricated panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards GS sheet and riveting shall be done from outside.
- Self adhesive Neoprene rubber / UV resistant PVC foam lining 5mm nominal thickness instead of felt shall be used between duct flanges and between duct supports in all ducting installation.
- All ducts shall be installed generally as per tender Drawings, and in strict accordance with approved shop drawings to be prepared by the Contractor. The contractor shall also carryout the feasibility study at site, coordination with other services and interior drawings before fabrication of duct. Any fabricated duct rejected due to these reasons shall not be paid and only final measured and installed duct shall be certified for payment.
- The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of these Specifications and Drawings. The work shall meet with the approval of Client / Consultant 's site representative in all its parts and details.
- All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown on the Drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to one side (the required area being maintained) all as per the site requirements.
- If a duct cannot be run as shown on the Drawings, the Contractor shall install the duct between the required points by any path available, in accordance with other services and as per approval of Client / Consultant's site representative. Fabrication of duct shall be commenced only after verifying the feasibility at site.
- All duct work shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angle/channel under ducts at no greater than 2

meter centre. All vertical duct work shall be supported by structural members on each floor slab. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods and angles/ channels shall be hung through these cleats. Duct support shall be through dash /anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats.

- Ducting over furred ceiling shall be supported from the slab above, or from beams, after obtaining approval of Client / Consultant's site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other Contractor's work in the building. All supports of pipe shall be taken from structural slab/wall by means of fastener.
- Where ducts pass through brick or masonry openings, it shall be provided with 25 mm thick TF quality expanded polystyrene around the duct and totally covered with mortar for complete sealing. Contractor shall ensure that contact between metal duct and mortar is avoided.
- All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a fire resistant double flexible connection, located at the unit discharge. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 10 cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.
- Duct shall not rest on false ceiling and all the supports shall be provided from slab only
- Suitable arrangement shall be provided in duct for fixing of duct smoke sensor (supplied by other vendor).
- Toilet exhaust duct shall be provided with goose necking as shown in design drawings and exhaust shall continue operation in case of fire.
- PVC washers shall be provided at two different metallic joints to avoid bi-metallic corrosion.

14.4 DAMPERS

- All duct dampers shall be opposed blade louver dampers of robust 16 G GSS construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.

- Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and accessible through suitable access door in the duct. Every damper shall have an indicating device clearly showing the damper position at all times.
- Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.

14.5 SUPPLY AND RETURN AIR DIFFUSERS & GRILLS

- Supply and return air diffusers shall be as shown on the Drawings and indicated in Bill of Quantities. The diffusers shall be powder coated & made from extruded aluminium section as specified in Bill of quantities.
- Supply air diffusers/grills with volume control dampers shall be provided for all air-conditioned areas. Return air diffusers/grills of air conditioned areas shall be without VCD. Diffuser neck velocities shall be restricted below 2 m/s.
- Rectangular Diffusers shall be steel / extruded aluminium construction, square & rectangular diffusers with flush fixed pattern for different spaces as per BOQ these shall be selected in consultation with the Client / Architect / Consultant's representative. These shall be procured only after obtaining written approval from Client / Architect / Consultant's representative for each type of diffuser.
- Supply air diffusers shall be equipped with fixed air distribution grids, removable key-operated volume control dampers, and anti-smudge rings as required in specific applications, and as per requirements of Bill of quantities. All extruded aluminium diffusers shall be provided with removable central core and concealed key operation for volume control damper.
- Linear Diffuser shall be extruded aluminium construction with removable core, one or two way blow type. Supply air diffusers shall be provided with volume control / balancing dampers within the supply air collar. Diffusers for different spaces shall be selected in consultation with the Client / Architect / Consultant's representative, and provided as per requirements of Bill of quantities. All diffusers shall have volume control dampers of extruded aluminium construction anodized in mat black shade.
- Slot Diffuser shall be extruded aluminium construction multislot type with air pattern controller provided in each slot. Supply air diffusers shall be provided with Hit & Miss volume control dampers in each slot of the supply air diffusers. Diffusers for different spaces shall be selected

in consultation with the Client / Architect / Consultant's representative and provided as per requirement of Bill of Quantities.

- All the supply air diffusers shall be provided with acoustically insulated plenum box. The insulation material for the supply air diffuser plenum box shall be 12 mm thick open cell cross linked polyolefin insulation.
- Design of all diffusers and grills shall be matching with the lighting fixture, false ceiling and other fittings. Prior approval of Purchaser shall be obtained for the location, type & colour code of diffusers/ grills.

14.6 FIRE & SMOKE DAMPERS (UL 555S LISTED & CERTIFIED)

- All supply and return air ducts crossing fire rated walls, and floor crossings shall be provided with Motor operated Fire & smoke damper of 180 minutes fire rating as per UL555S listed and certified damper. These shall be of multi-leaf type and provided with Spring Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span. The damper shall shut automatically in case of power failure.
- Fire damper blades and outer frames shall be of 16G galvanized steel construction fitted with 18 gage extended sleeves 150mm length on both sides. The damper blade shall be pivoted on both ends using chrome plated spindles in self lubricated bronze bushes. Stop seals shall be provided on top and bottom of the damper housing made of 16G galvanized sheets steel. For preventing smoke leakage metallic compression seals will be provided.
- The electric actuator shall be energized either upon receiving a signal from smoke detector. The fire damper shall also close upon sensing temperature rise in supply air ducts thru the electronic temperature sensor.
- Each damper shall be provided with its own control panel, mounted on the wall within the AHU room and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have atleast the following features:
 - Potential free contacts for AHU fan ON/ OFF and remote alarm indication.
 - Accept signal from external smoke / fire detection system for tripping the electrical actuator.
 - Test and reset facility.
 - Indicating lights / contacts to indicate the following status:
 - Power Supply On
 - Alarm

Damper open and close position.

- Actuators shall be mounted on the sleeve by the damper supplier in his shop and shall furnish test certificate for satisfactory operation of each Motor Operated Damper in conjunction with its control panel. Control panel shall be wall mounted type and located in AHU room or nearest electrical room.
- The control panel of the fire damper shall suitable for independent and series connection operation. The panel shall be configured Master/Slave concept to receive the signal for all actuator thru master panel. The internal control wiring shall be part of fire damper scope.
- It shall be HVAC Contractor's responsibility to co-ordinate with the Fire Alarm System Contractor for correctly hooking up the Motor Operated Damper to Fire Detection / Fire Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.
- HVAC Contractor shall demonstrate the testing of all Dampers and its control panel after necessary hook up with the fire protection / fire management system is carried out by energizing all the smoke detectors with the help of smoke.
- HVAC Contractor shall provide Fire retardant cables (FRLS) for satisfactory operation and control of the Damper.
- HVAC Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing at site. Installation of damper shall be as per manufacturer recommendation or as per CLIENT Instructions. Damper shall be provided with GI sleeves extending on either side of wall up to 3 inches to 6 inches. The damper shall be supported with structural wall by providing 32 mm x 32 mm angle frame on all sides of sleeve. Damper shall be supported with structure using a fastener. Installation details in form of sketch shall be submitted prior to execution and gotten approved from Client / Architect / Consultant's representative.
- Fire/smoke damper shall be provided with factory fitted sleeves; however, access doors shall be provided in the ducts in accordance with the manufacturer's recommendations. The location of actuator shall not foul with the fire rated wall. However, damper shall be placed on the fire rated wall.
- Filling-up the annular gap between wall and duct / smoke damper with fibre glass and applying fire sealant
- AMCA Certification need to provided for air performance of fire damper.

14.7 FLEXIBLE DUCTING

- The flexible ducts used to tap supply air shall be of high quality thermally insulated duct. The insulation material shall be fiberglass and thickness of the insulation shall be minimum 25 mm thick. The density of the insulation shall be not less than of 16 kg / cum with a minimum R Value of 4.2. All thermal performance (R-Values) shall be certified by Underwriters Laboratories in accordance with ADC Flexible Duct Performance and Installation Standard (1991) using ASTM C-518 (1991), at installed wall thickness, on flat insulation only. Flexible duct shall also comply to the following standards and third party certification UL 181, NFPA 90A & 90B
- The inner core of the products shall be air-tight and designed for low-to-medium operating pressures in HVAC systems. A double lamination of tough polyester shall encapsulate a steel wire helix to form the air-tight inner core. The double-layer core of each product shall be wrapped in multiple thicknesses of fiberglass insulation. The product shall be sheathed in a rugged and durable tri-directionally reinforced, metalized polyester jacket. Flexible ducts shall be cut to the required size to ensure a curved connection between the main duct and the air terminal plenum. The contractor shall not join any small flexible pieces by any foreign materials before installation. The minimum length of the flexible duct shall not be less than 750 mm in length. A groove of 2 mm shall be made on the round collars to ensure that the spiral wire inside the flexible duct shall be fitted ahead of the groove. Stainless steel metal clamps, which are made out of 8-mm wide band with lifted edges, shall be used to tighten the connection of the flexible ducts on the round collars of the plenums. On the flexible ducts, the clamp is fitted with a flip up and quick locks tightening ahead of ease of fixing. The contractor shall ensure that all the flexible ducts wherever installed shall follow the above procedure. The contractor has to obtain the approval from the CLIENT managers before starting the actual installation. The flexible duct should not be rested on false ceiling frame / tiles / boards. The flexible ducts shall be hanged from the roof slab.

14.8 TESTING AND BALANCING

- After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection. The entire air distribution system shall be balanced using an anemometer. Measured air quantities at fan discharge, at various outlets and return air shall be identical to or less/excess than 5 percent in excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is

completed so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be provided with completion documents.

15. INSULATION**15.1 SCOPE**

The scope of this section covers the supply and application of insulation of various type insulation materials with various types of application as specified in the drawings and BOQ for sheet metal ducting - acoustic lining and thermal, refrigerant and drain pipes, etc.,

15.2 NITRILE RUBBER INSULATION

- Insulation material for Duct insulation shall be Elastomeric Nitrile Rubber having anti-microbial protection. The anti-microbial product protection shall be an integral part of insulation that is built-in during the manufacturing process and the product protection should not allow the microbes to function, grow, and reproduce. The duct insulation shall have self-adhesive backing with a peel-off cover for easy installation at site. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/moK at an average temperature of 20°C. The product shall have temperature range of -40°C to 105°C. The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O' Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990. Water vapour permeability shall not exceed 1.74×10^{-14} Kg/m.s.Pa, i.e. Moisture Diffusion Resistance Factor or ' μ ' value should be minimum 10,000 according to EN 12086.
- Insulation material for Duct Acoustic Lining shall be processed Open cell Nitrile Rubber foam having anti-microbial protection. The material should be dust and fibre free. The density shall be within 140-180 Kg/m³. Insulation material for Duct thermal lining shall be processed closed cell Nitrile Rubber foam having anti-microbial protection. The density shall be within 45-60 Kg/m³. Ducts so identified and marked on Drawings and included in Bill of Quantities shall be provided with acoustic lining for a distance of minimum 5 meters. The inside surface for the ducts shall be covered with adhesive recommended by the manufacturer. Cut Foamed sheets into required sizes apply adhesive on the foam and stick it to the duct surface

15.3 INSULATION - APPLICATION

- Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work. Measurement of surface dimensions shall be taken properly to cut the insulation sheets

to size with sufficient allowance in dimension. Material shall be fitted under compression and no stretching of material shall be permitted. A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations. The adhesive shall be strictly as recommended by the manufacturer.

- Each lot of insulation material delivered at site shall be accompanied with manufacturer test certificate for thermal conductivity values and density. Samples of insulation material from each lot delivered at site may be selected by Client / Consultant's site representative and gotten tested for thermal conductivity and density at Contractor's cost. All joints shall be sealed properly with adhesive, which shall provide similar vapour barrier as the original insulating material.

15.4 RECOMMENDED ADHESIVE:

In all cases, the manufacturer's recommended Adhesive should be used for the specified purpose. The adhesive shall have low VOC and shall confirm with LEED/IGBC guidelines.

15.5 EQUIPMENT INSULATION

Chilled water pump, expansion tank, etc shall be insulated minimum 48mm thick nitrile rubber insulation. Care shall be taken to apply insulation in a manner as to allow the dismantling of pumps without damaging the insulation. The insulation shall be covered with 24 Gauge aluminium spiral casing for exposed application and 26 Gauge GI spiral casing for indoor application.

15.6 PROTECTIVE COATING OVER INSULATION

To provide mechanical strength and protection from damage & UV rays all exposed duct insulation as indicated in BOQ shall be covered with woven glass fabric cloth. The glass fabric shall be applied with one coat of fire proof epoxy or acrylic compound. The coat shall be allowed to cure to non stick state. Subsequently second coat of compound shall be applied to give a tough and smooth finish to the insulated surface.

15.7 ACOUSTIC LINING OF MECHANICAL ROOMS

- The walls of the air conditioning plant room and air handling unit rooms may be provided with acoustic lining of fiberglass as per Bill of Quantities and as shown on the Drawings. The surface shall be cleaned and frame work of 22 gauge GI fabricated Channels 25 mm x 50 mm screwed back to back at 60 cm centres shall be provided vertically and horizontally so that 60 x 60 cm squares are formed. The gaps between frames shall be filled with 48kg/cum density, 50 mm thick about 60 cm x 60 cm cut panels of polyester fibre wool. The entire surface shall then be covered with Tissue paper and then 26 gauge perforated aluminium sheet, 60 cm or 120 cm wide having atleast 40 percent perforations with 3mm dia holes, fixed with sheet metal screws. Over-lapping of sheets shall be covered with Aluminium beading. Acoustic lining of walls shall be terminated approximately 15 cm above the finished floor to prevent damage to insulation due to accidental water-logging in plant/AHU rooms.
- The walls of the air conditioning plant room and air handling unit rooms may be provided with acoustic lining of fibre-glass as per Bill of Quantities and as shown on the Drawings. Modular removal type wall acoustic paneling system with 0.8 mm thick 600mm x 600 mm Aluminium hydraulic pressed panels by Clip on type method and insulated with 48 Kg. /m³ density, 50 mm thick Fiberglass wool including Clips and consumables complete

Installation Procedure:

- Fix "U" Clamp on to the wall /ceiling, made out of 1.0 mm thick GI with the help of fasteners/Rawl plugs
- Fix pre-fabricated compressed G.I. Carriers having a thickness of 0.6 mm and fixed in to the "U" Clamp by friction fit method horizontally over Wall/Ceiling at an interval of 600 mm to receive pre fabricated panels.
- Fix Fiberglass wool having density of 48 Kg./m³, 50 mm thickness along with Fiberglass tissue on to the wall / ceiling.
- Fix pre-fabricated Aluminium panels of 0.6 mm thickness perforated modular type wall acoustic removal type panels with a dimension of 600 mm x 600 mm with clip on lock arrangements on the compressed clip already fixed on wall / Ceiling
- The sides of the panels are raised suitably to lock in to the clips by friction fit method.

16. VARIABLE FREQUENCY DRIVES FOR HVAC SYSTEM**16.1 GENERAL SPECIFICATIONS:**

- The VSD must comply with Equipment Standard IEC/EN 61000-3-12: Limits for harmonic currents produced by equipment connected to public low voltage systems.
- All VSDs shall have the same customer interface, including multilingual control panel, I/O connections and software, regardless of power rating, voltage or enclosure (IP class).
- The control panel must always be delivered with the drive and shall include the following functionalities:
Full-text messages. Panels with only message codes are not accepted.
Removable without tools
Hand-Off-Auto functionality & Dedicated Help button
Parameter copy function from one drive to another
- The VSD must not be a limiting component in the drive-motor package. All VSDs must produce enough current to provide rated motor (IE3) kW power at -15 up to +50 °C ambient temperature continuously (24/7/365) even when mounted side by side.

The manufacturer's statement on output currents available 24h/day at 40°C and 50°C must be provided in writing.

- The VSD should have the capability to be configured without VSD power supply by using an optional configuration device. Also, there shall be a possibility to configure or adjust VSD parameters even if the VSD power is switched off.
- The VSD should have the capability for programming load curves. Under-load and over-load curves must be user defined.
- The VSD shall have an override function. Motor rotation direction shall be selectable in override mode. The manufacturer's description on override function must be provided in writing.

- Electronic boards must be coated to support longer lifetime of the drive. The manufacturer's statement must be provided in writing.
- Supply Voltages: 3 phase, 380 to 480 V, +10/-15%
Supply Frequency: 48 to 63 Hz.

16.2 PROTECTION CLASS & ASSEMBLY METHOD

VSDs must be IP20 in case of panel mounting.

Side-by-Side mounting must be possible.

16.3 ENVIRONMENTAL LIMITS

Ambient temperature: Transportation and storage -40 to 70 °C

Ambient temperature: Operation -15 to 50 °C (no frost allowed)

Altitude: Rated output current available at 0 to 1000m; reduced by 1% per 100m over 1000m up to 2000m.

Relative humidity lower than 95%(without condensation)

16.4 STANDARD FEATURES

- The VSD must have inbuilt EMC filters as standard. The range of VSDs shall conform to the European Union Electro Magnetic Compatibility (EMC) Directive, a requirement for CE marking. VSDs must comply with EMC Directive 89/336/EEC with supplements and Product Standard EN 61800-3
- Changed parameters list shall be available in order to assist commissioning and troubleshooting. Also, the VSD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to reduce energy consumption by up to 10% and lower audible motor noise.
- The VSD shall include an over modulation feature, which will automatically increase the output voltage. It shall have programmable "Sleep" and "Wake up" functions to allow the drive to be started and stopped from the level of a process feedback signal.

- For smooth output waveform, the switching frequency of VSD shall be default 4kHz and shall be selectable from 1kHz to 12kHz.
- If the input reference (4 to 20mA or 0 to 10VDC) is lost, the VSD shall give the user the option of: (1) stopping and displaying a fault; (2) running at a programmable preset speed and displaying an alarm; (3) hold the VSD speed based on the last good reference received and displaying an alarm. The drive shall be programmed to signal this condition via a control panel warning, relay output and/or over the serial communication bus.
- The overload rating of the VSD shall be 110% of its rated current for 1 minute every 10minutes and with a minimum of 130%.
- Overload ability must be available at all times – not only at start.
- The VSD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to set point (flying start) without safety tripping or component damage.
- The VSD shall have the ability to automatically restart after an over current, over voltage, under voltage, or loss of input signal protective trip. The number of restart attempts minimum 5, trial time from 1s to 600s and delay time of up to 120 sec shall be programmable.
- The VSD shall have cooling fans that are designed for easy replacement without removing the VSD from the wall or removal of circuit boards. The VSD cooling fans shall operate only when required, to extend the fan and bearing operating life. Operating temperature will be monitored and used to cycle the fans on and off as required.
- There shall be a flux breaking capability, where the VSD increases the motor magnetization to dissipate the extra energy whenever small braking power is required. It shall be possible to use the braking to decelerate the motor from one speed to another – not only for stopping the motor.
- Power Loss Ride – Through shall be available. If the incoming supply voltage is cut off, the VSD continues to operate using the kinetic energy of the rotating motor. The drive continues to be operational as long as the motor rotates and generates energy.

The VSD shall have the following minimum I/O features for connectivity

The number of digital inputs required is 4

The number of analog inputs required is 2

The number of analog outputs required is 1

The number of relay outputs required is 1

The number of digital outputs required is 1

16.5 PRODUCT COMPLIANCE

Low Voltage Directive 73/23/EEC with supplements

Machinery Directive 98/37/EC & EMC Directive 89/336/EEC with supplements

EN 61800-3, IEC/EN 61000-3-12 & Quality assurance system ISO 9001

Environmental system ISO 14001

CE, UL and cUL approvals

GOST R certificate, RoHS Directive 2002/95/EC

16.6 PROTECTION FUNCTIONS

The following protection functions shall be available:

Overvoltage controller & Under voltage controller

Earth-leakage supervision, Motor short-circuit protection & Overcurrent protection

Output and input switch protection

Phase-loss detection (both motor & line)

Under load supervision

Overload supervision & Stall protection

16.7 USER INTERFACES – DETACHABLE CONTROL PANEL

The control panel shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate “bumpless transfer” of speed reference when switching between

“Auto” and “Hand” modes. There shall be a fault reset button and a dedicated “Help” button on the control panel. The Help button shall include “on-line” assistance for programming and troubleshooting.

The control panel shall include a backlit LCD. The display shall be in complete words, for programming and fault diagnostics (alphanumeric codes are not acceptable). The keypad shall utilize the following interactive assistance to guide the user:

Start-up/ Programming assistants

Diagnostic assistant

The VSD shall be utilize pre-programmed application macros, specifically designed to facilitate start-up in typical Pump applications such as supply and return fans, condensers and booster pumps. The application macros shall provide one command to reprogram all the relevant parameters and customer interfaces for a particular application to reduce programming time. The VSD shall have two user macros to allow the end user to create, save and change between custom settings like winter/summer or day/night.

The control panel must be detachable IP20 protection class without tools to allow easy commissioning and programming of multiple VSDs.

Dedicated features for pumps and fans which include

- Supervision of inlet/outlet pressure
- Pump cleaning functions
- Pipe fill functions
- Detection of underload/overload

16.8 USER INTERFACES – SERIAL COMMUNICATIONS

- The VSD shall have an EIA-485 (RS-485) port as standard. Protocol always available as embedded into the VSD memory shall be MODBUS RTU.
- Serial communication capabilities shall include, but not limited to: run-stop control, speed set adjustment, proportional/integral/derivative (PID) control adjustments. PID set point adjustment, current limit, acceleration/deceleration time adjustment and lock/unlock keypad.

The drive shall have the capability of the allowing the DDC to monitor feedback such as process variable feedback, output speed/ frequency, current, torque, power(kW), kilowatt hours (resettable), operating hours (resettable), drive control location (hand or auto) and drive temperature.

- The DDC shall also be capable of monitoring the VSD relay output status, digital input status and all analog input and analog output values. All the diagnostic warning and fault information shall be transmitted over the serial communications bus. DDC shall be able to activate VSD fault-reset via fieldbus. A minimum of 15 fieldbus parameters shall be capable of being monitored.
- The VSD shall allow the DDC to control the drive's digital and analog outputs via serial interface. This control shall be independent of any VSD function (Free I/O). For example the analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive's digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all the drive's digital and analog inputs shall be capable of being monitored by the DDC system.
- The VSD shall include two PID loops one for control of motor and one independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass valve control, chilled water valve control etc. Both the VSD control PID loop and the independent PID loop shall continue functioning even if the serial communication connection is lost. The VSD shall keep the last good set-point command and last good DO & AO commands in memory in the event that the serial communications connection is lost.

16.9 WARRANTY

All VSDs must be covered with a worldwide warranty of minimum 24 months from the date of commissioning.

17. HVAC – BUILDING MANAGEMENT SYSTEM**17.1 SCOPE**

This specification comprises the concept and codes to be followed for the Integrated Building management System

The BAS shall integrate smallest sensor to the operator workstations.

Integration shall mean all the parts of the system are connected together through software and shall share the information.

The integration of the systems shall be achieved through software program, electronic components and hardware packaging and communication network.

17.2 AUTOMATION LEVEL:

The logic written on the DDC shall determine the level at which the actual processing takes place.

The processes are carried out at DDC controllers for autonomous control (all control functions shall be independent of the network/other DDCs).

17.3 DDC PROGRAMMING SOFTWARE

The software shall be a graphically programming tool. It enables the user to

Make a function diagram to parameters.

commission all the automation station

Change the parameters etc when the system is in operation.

The software shall be windows based.

The software shall be modular, structured and shall be based on Window 32-bit technology

17.4 SYSTEM DESIGN

The DDC controller shall be a decentralized module with autonomous intelligence

It shall be able to process, store and handle a large volume of data and meet all the demands placed on it.

It should not need to be supported / located centrally.

The System shall co-ordinate the flow of data in both directions.

It shall be responsible for the communication upwards with the management station, on the same level with other system controllers, and downwards with the field devices.

17.5 THE DATA EXCHANGE

The interface transmits and receives data both via the DDC bus and trunk bus via System controller.

The tasks of the interface shall include:

Processing the installed DDC data points.

Converting local system controller addresses (DDC) into physical DDC module addresses.

Monitoring network and DDC bus communication.

Optimizing communication between the interface and the system controller.

Synchronizing date, time adjustments in the interface and the DDC modules.

17.6 THE DDC CONTROLLERS

The direct digital controller shall be designed with functions distributed both physically and functionally over the field controllers.

The DDC shall be truly autonomous with peer-to-peer communication.

The DDC shall have the following minimum features:

32-bit processor:

Inbuilt real time clock with a battery backup for a minimum of 3 years.

Inbuilt memory for viewing any historic data base at least for 300 KB events of various signals in each controller.

Stipulated parameters such as temperature, RH, pressure etc shall be stored in each controller.

These parameters shall be available for viewing/uploading in case central system is switched off or communication network is under maintenance.

Provision shall be available for connecting laptops or PC directly to DDC for local evaluation.

The autonomous controller for each unit shall be with EPROM and EEPROM.

It shall also have Flash ROM chip of required capacity with function blocks for performing required closed loop and open loop (interlocks) functions at various locations.

The controller shall be housed in proper lockable enclosure, providing for required data acquisition, processing capability etc. as required.

The controllers shall be completely wired.

The controllers shall have all interface relays required for interfacing with external system like MCC etc.

Autonomous DDC Controllers shall be able to access any data directly with any other DDC Controller or combination of controllers on the network without depending on the central processing/monitoring station.

These controllers shall also work without dependence on Main operating station.

DDC controllers shall be provided with I/O points as per Schedule.

Each DDC controller's location shall have 10% spare capacity for future expansion.

The expansion /addition of I/Os shall be possible

The DDC controllers shall also house the associated terminal blocks, power supply, relays (with changeover contacts), etc.

They shall also have self-diagnostic (testing) capabilities to monitor healthiness of the controller.

17.7 THE DDC CONTROLLERS - APPLICATIONS

HIGH side works:

All the High side works like chiller controls, Primary and secondary pumps controls shall be included in the Part of Chiller plant manager system (Hard point and Soft Point).

Downstream Works:

All the AHU's, Ventilation fans along with necessary control valves are controlled and monitored by the Standalone DDC and BAS system from IBMS room. The automatic controls shall include the following works:

Starting and controls of Air handling units

Ventilation fans.

The BAS Contractor shall prepare full detailed control schemes, logic and wiring diagrams for the Engineer's approval.

17.8 FUNCTION OF BUILDING MANAGEMENT SYSTEM.

The various functions that this system shall perform are as follows:

The system shall ensure sequential and automatic start/stop of the various air-conditioning equipment based on time schedule and ambient temperature.

It shall maintain design inside conditions, within the specified limits, throughout the year.

It shall monitor the start/stop and faults of units like filter clogging, overload trip etc.

It shall maintain duty cycle to provide equal run time for all equipment wherever applicable. The BAS system and the addressable fire detection system should be compatible to each other to enable their connectivity.

All goods and materials to be used in the works shall be of the most recent or current models and incorporate all recent improvements in design and materials.

17.9 ACCURACY

Control and measuring devices shall have the following limits of accuracy.

Temperature : +/- 1 deg 'C' over the range.

Pressure : +/- 1.5% of measured value.

Humidity : +/- 5% over the range of 10% to 90% RH.

- The supplier shall provide a system that is based on standard hardware suitable for local technology plus standard software (basic-operation and user software) for AHU/CSU controllers and central CMS.
- The system shall be 'open', i.e., fully upgradeable.
- The system shall be designed for safety and reliability. Should the PDM ever fail, the operation of the DDC substations shall be unaffected.
- Should a DDC substation ever fail, then the other DDC substations shall function normally.
- The system reliability shall be augmented by additional precautions: -
- Optimum distribution of the functions to the DDC.
- Suitable number of data points per DDC.
- System shall be user-friendly and the user programs of the Main operator station at BMS room level shall be clearly laid out (general overview, plant schematics with Graphics, well-documented program listings, on-line help facility etc.).
- Text alterations, priority changes, screen-mask texts etc. shall be easy to comprehend.
- In each DDC substation there shall be a provision for connecting a laptop for programming the Data's.

- The structure of the user software - shall be modular and simple design - allowing the operator to make changes for project – related requirements.
- For operation, alteration and maintenance, no EDP (Electronic Data Processor) specialists should be needed. No knowledge of programming languages such as Basic, Pascal, Fortran, 'C' etc. should be called for.

The control loops shall be programmed using the software in interactive mode. They shall be assigned to the various analog inputs and outputs as desired.

NOTE: The Copy of all test certificates shall be produced for verification.

17.10 FIELD DEVICES AND MISCELLANEOUS EQUIPMENT

17.10.1 General Requirements:

All controls shall be capable of operating in ambient conditions varying between 0-55 deg.C and 90% R.H. non-condensing.

All Control devices shall have a 20 mm conduit knockout. Alternatively, they shall be supplied with adaptors for 20 mm conduit.

17.10.2 Ancillary items:

When items of equipment are installed in the situations listed below, the BAS contractor shall include the following ancillary items:

17.10.3 Weather Protection (for external)

All devices required to be weatherproofed are detailed in the Schedule of Quantities. IP ratings for the equipment are mentioned in the respective section.

17.10.4 Pipework Immersion

Corrosion resisting pockets of a length suitable for the complete active length of the device, screwed ½" (13 mm) or ¾" (20 mm) NPT suitable for the temperature, pressure and medium.

Duct Mounting (Metal or Builders Work)

Mounting flanges, clamping bushes, couplings, locknuts, gaskets, brackets, sealing glands and any special fittings necessitated by the device.

17.10.5 Additional features

Concealed Adjustment: All two position switching devices shall have concealed adjustment unless detailed.

Operating Voltage: All two position switching devices shall operate on 230V a.c and all accessible live parts shall be shrouded. An earth terminal shall be provided.

17.10.6 TEMPERATURE SENSOR

- Temperature sensors for space, pipes and ducts, shall be of the Resistance Temperature detector (RTD) type or thermistor. These shall be two wire type and shall conform to the following specifications :
- Immersion sensors shall be high accuracy type with a high resistance versus temperature change. The accuracy shall be at least +/- 1 degC over the range
- Immersions sensors shall be provided with separate stainless steel thermo well.
- The connection to the pipe shall be screwed ½ inch or ¾ inch NPT (M). An aluminum sleeve shall be provided to ensure proper heat transfer from the well to the sensor. Terminations to be provided on the head.
- The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections.
- Duct temperature sensors shall be with rigid stem and of averaging type. These shall be suitable for duct installation.
- Outdoor air temperature sensor shall be provided with a sun shield.
- The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.
- The temperature sensors may be of any of the following types :

- PT 100
- NI 100

17.10.7 HUMIDITY SENSOR

- Space and duct humidity sensors shall be of capacitance type with an effective sensing range of 10% to 90% RH.
- Accuracy shall be +/- 5% or better. Duct mounted humidity sensors shall be provided with a sampling chamber.
- Wall mounted sensors shall be provided with a housing. The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections.
- The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

17.10.8 DIFFERENTIAL PRESSURE SWITCH FOR AIR SYSTEMS

- These shall be diaphragm operated. Switches shall be supplied with air connections permitting their use as static or differential pressure switches.
- The switch shall be of differential pressure type complete with connecting tube and metal bends for connections to the duct. The housing shall be IP 55 rated.
- The pressure switches shall be available in minimum of 3 ranges suitable for applications like Air flow filter, clog etc.
- The contact shall be 230 VAC, 1 A rating.
- The switch shall be supplied suitable for wall mounting on ducts in any plane. It should be mounted in such a way that the condensation flow out of the sensing tips. Proper adaptor shall be provided for the cables.
- The set point shall fall within 40%-70% of the scale range and I have differentials adjustable over 10%-30% of the scale range.

- The switches shall be provided with site adjustable settings and with 2 NO/NC contacts.

17.10.9 AIR FLOW SWITCHES

- Air flow switches shall be selected for the correct air velocity, duct size and mounting attitude.
- If any special atmospheric conditions are detailed in the Schedule of Quantity the parts of the switches shall be suitably coated or made to withstand such conditions.
- These shall be suitable for mounting in any plane. Output shall be 2 NO/NC potential free. Site adjustable settings shall also be provided.

17.10.10 LEVEL SWITCH

The level switches shall have to meet the following requirement:

Type	:	Capacitance type/Conductivity type
Mounting	:	To suit application.
Float material	:	SS
Stem Material	:	SS
Output	:	2 NO, 2 NC potential free
Switch Enclosure	:	IP 55

17.11 SPECIFICATION FOR THE WORK OF PROVIDING BMS WORKS

- The works shall be done as per standards.

- The work shall be supervised by qualified Engineer.
- The layout of the work shall be given by Engineer-in-charge or his duly authorized representative at site of work.
- The following wiring shall be done in separate conduits.
 - Power wiring
 - Control wiring
 - Signal wiring
- The MS conduit shall be of IS marked, stove enameled. The conduits shall be delivered to site in original bundles and each length shall bear the label of the manufacturer. The materials brought at site shall be with proper challan with quantity mentioned on it.
- The makes of material have been indicated in the list of approved makes. No other make will be acceptable. The material to be used in the work shall be got approved from the Engineer-in-charge before its use at site. The Engineer-in-charge shall reserve the right to instruct the contractor to remove the material which, in his opinion, is not as per specifications
- All hardware material such as nuts/bolts /screws/washers etc. to be used in the work shall be zinc/cadmium galvanized iron.
- The outer surface of conduits including all bends, unions, tees, junction boxes etc. forming part of the conduit system, shall be adequately protected against rust. The conduits are to be painted with 2 coats of red oxide paint before they are fixed. All bare threaded portions shall be treated with anticorrosive preservative (or) approved plastic compound.
- At the time of laying conduit pipe in the slab in recess, the contractor will keep fish wires of 18 SWG GI wire throughout conduit pipe and will have to take special care so that the conduits do not pass through air-conditioning ducts, grills, beams etc. If any, such necessity is foreseen special written permission of the Engineer-in-charge will be obtained before such work is carried out. In case of failure, the contractor will not be paid on this account and the work has to be redone by the contractor as per direction of Engineer-in-charge.

- The conduits are to be concealed in the walls before the walls are plastered and work is to be done in coordination with building work. Any damage thus done will have to be made good by the contractor at his own risk and cost. The conduit pipe should mechanically and electrically continuous.
- Wherever it is not possible to provide rigid conduits, flexible metallic pipe shall be provided for running the wires. However, such arrangement has to be kept to the barest minimum and to be done only with the prior approval of Engineer-in-charge.
- Different colour painting shall be done for different wiring as per the Standards.

17.12 CONDUITS AND WIRING

Prior to laying and fixing of conduits, the contractor shall carefully examine the drawings indicating the layout, satisfy himself about the sufficiency of number and sizes of conduits, sizes and location of conduits and other relevant details. Any discrepancy found in the drawings shall be brought to the notice of Architect/Engineers. Any modifications suggested by the Contractor shall be got approved by the Architect /Engineers before the actual laying of conduits is commenced.

17.13 CONDUITS

- The work shall be done as per standards for Electrical works as amended from time to time and Indian Electrical Rules as amended up to date.
- The layout of the work will be given by the Engineer-in-charge or his duly authorized representative at site of work.

17.14 CONNECTIONS:

All jointing methods shall be subject to the approval of the Engineer-in-charge.

17.15 DRAWING OF CONDUCTORS:

- While drawing insulated wires/cable into the conduits, care shall be taken to avoid scratches and kinks which may cause breakage of conductors.
- Insulation shall be shaved off like sharpening of a pencil and it shall not be removed by cutting it square to avoid depression/cutting of conducting material.

- Strands of wires shall not be cut to accommodate & connect to the terminals. Terminals shall have sufficient cross-sectional area to take all the strands.
- No wire shall be drawn into any conduit until all work of any nature that may cause injury to wire is completed. Before the wires are drawn into the conduit, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction.
- Where wires are connected to detectors, or panel, sufficient extra length of wires shall be provided to facilitate easy connections and maintenance.
- Only licensed supervisors/wiremen shall be employed for cabling and other connected work. Only approved make of cables shall be used. The cables shall be brought to the site in original packing.

17.16 MODE OF MEASUREMENT

Signal Cable

The cabling running between DDC controllers to the field devices shall be termed as signal cabling. This cabling along with conduits shall be payable on running meter basis.

Communication Cable

The cabling running between the system integration units to the DDC controllers shall be defined as communication cable. This cable shall also be measured on per running metre basis.

LAN Cable

The cable connecting various system integration units to the control station shall be termed as LAN cable. This cable shall be measurable on unit length basis.

17.17 SPECIFICATION FOR CABLES:

The cable shall be manufacture/tested as per the latest IS standards.

The signal cable shall be of the following specifications: (communication cable)

Wire	:	multistrand Copper
Size	:	as per BOQ
No. of conductors	:	as per BOQ
Shielding	:	Overall belt foil aluminum polyester shield.
Jacket	:	Chrome PVC

17.18 ENCLOSURES FOR CONTROLLERS AND ELECTRICAL PANELS

- All the controllers shall be housed in Lockable Vandal proof boxes which shall either be floor mounted or wall mounted. These shall be free standing, totally enclosed, dust and vermin proof and suitable for tropical climatic conditions.
- The panel shall be metal enclosed 14 SWG CRCA powder coated sheet steel cubicle with gaskets between all adjacent units and beneath all covers to render the joints dust proof. All doors and covers shall be hinged and latched and shall be folded and braced as necessary to provide a rigid support. Joints of any kind in sheet metal shall be seam welded with welding slag grounded off and welding pits wiped smooth with plumber metal.
- All panels and covers shall be properly fitted and secured with the frame and holes in the panels correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with nuts. Self-threading screws shall not be used in the construction of control panels. Knockout holes of approved size and number shall be provided in the panels in conformity with the location of incoming and outgoing conduits/cables. Clamps shall be provided to support the weight of the cables. The dimension of the boxes shall depend on the requirement with the colour decided in consultation with the PMC/Employer

18. MODE OF MEASUREMENT

For variable items like sheet metal ducting, insulation, piping works, cabling etc., the following measurement procedure shall be adopted for billing purposes.

18.1 DUCTING

Unless otherwise specified, measurements for ducting for the project shall be on the basis of centre-line measurements described herewith:

- Duct Work shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external surface area shall be calculated by measuring the perimeter comprising overall width and depth, including the corner joints, in the centre of each duct section, multiplying with the overall length from flange face to flange face of each duct section and adding up areas of all duct sections. Plenums shall also be measured in similar manner.
- For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway between large and small diameter shall be adopted, the length of tapered duct section shall be the centre line distance between the flanges of the duct section.
- For special pieces like bends, tees, reducers, branches and collars, mode of measurement shall be identical to that described above using the length along the centre line.
- The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles with double nuts for supports, rubber strip 4 mm thick between duct and support, vibration isolator suspension where specified or required, inspection chamber / access panel, splitter damper with quadrant and lever for position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the Specifications. These accessories shall NOT be separately measured nor paid for.
- Special Items for Air Distribution shall be measured by the cross-section area perpendicular to air flow, as identified herewith:
- Grilles and registers - width multiplied by height, excluding flanges. Volume control dampers shall form part of the unit rate for registers and shall not be separately accounted.

- Diffusers - cross section area for air flow at discharge area, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.
- Linear diffusers - shall be measured by cross-sectional areas and shall exclude flanges for mounting of linear diffusers. The supply air plenum for linear diffusers shall be measured with ducting as described earlier.

18.2 DUCT INSULATION

The measurements for insulation of ducts shall be made in actual square metres of bare uninsulated duct surface through all dampers, flanges and fittings. In case of bends the area shall be worked out by taking an average of inner and outer lengths of the bends. Measurements for the dampers, flanges, fittings shall be measured for the surface dimension. The overlapping of insulation shall not be measured separately for billing purpose. In case of acoustic lining of air ducts, measurements of the bare inside duct surface in square meters, shall be final for billing purposes. The acoustic insulation of plenum boxes shall not measured separately as it is part of plenum box supply as specified in Spec / BOQ. The insulation/acoustic panels shall include cost of battens, supports, adhesives, vapour proofing, finished tiles/boards sheets as well as additional labour and material required for completing the work.

18.3 CHILLED WATER PIPING

- Unless specified otherwise, measurement for piping for the project shall be on the basis of centre line measurements described herewith.
- Piping shall be measured in units of length along the centre line of installed pipes including all pipe fittings, flanges (with gaskets, nuts, and bolts for jointing), unions, bends, elbows, tees, concentric / eccentric reducers, inspection pieces, expansion loops etc. The above accessories shall be measured as part of piping length along the centre line of installed pipes, and no special multiples of pipe lengths for accessories shall be permitted.
- The quoted rates for centre line linear measurements of piping shall include all wastage allowances, pipe supports including hangers, PUF supports, nuts, check nuts, vibration isolator suspension where specified or required, and any other item required to complete the piping installation as per the Specifications. None of these items will be separately

measured nor paid for. However, all valves (check / balancing / purge / butterfly / drain etc), strainers, thermometers, pressure gages shall be separately counted and paid as per their individual unit rates, which shall also include their insulation as per Specifications / BOQ description.

- All the extra CI & CM flanged valves shall be measured according to the nominal size in mm and shall be measured by number. Such valves shall not be counted as part of pipe length hence deduction in pipe length will be made wherever valves occur. All valves shall include two Nos. of flanges and two numbers 150mm long MS nipples, with one side threaded matching one of the valves, and other welded to the M.S. slip-on-flange. Rate shall also include the necessary number of bolts, nuts and washers, 3 mm thick insertion gasket of required temp. grade and all items specified in the specifications.
- The rates quoted shall be inclusive of making connections to the equipment, tanks, pumps etc. and the connection made with an installed pipe line shall be included in the rates as per the B.O.Q. Tenderer shall get pressure testing of pipes / measurements etc verified by the Client / Architect / Consultant's representative at site.

18.4 REFRIGERANT PIPE MEASUREMENTS

The pipe lengths specified in the BOQ shall deemed to be inclusive of all fittings like Bends, Elbows, Reducers, Pipe supports, clamps, etc. These will not be measured separately and paid for. The pipes shall be in unit length rounded off to the nearest centimeter and measured along the centre line of the pipe and fittings. The quoted unit rate for all pipes shall inclusive of all wastage allowances and also inclusive of necessary painting as per the standard color code.

18.5 PIPE INSULATION

Unless otherwise specified measurement for duct and pipe insulation for the project shall be on the basis of centre line measurements described herewith. Pipe Insulation shall be measured in units of length along the centre line of the installed pipe, strictly on the same basis as the piping measurements described earlier. The linear measurements shall be taken before the application of the insulation. It may be noted that for piping measurement, all valves, orifice plates and strainers are separately measurable by their number and size. It is to be clearly understood that for the insulation measurements, all these accessories including cladding, valves, orifice plates and strainers shall be considered strictly by linear

measurements along the centre line of pipes and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.

18.6 ACCESSORIES INSULATION

The insulation for accessories such as expansion tank, pumps, chillers, valves, etc. shall be considered in the respective items and hence shall not be measured separately.

18.7 CABLING

Payment for Cabling works shall be effected on the basis of linear measurement measure from gland to gland. Any looping provided in cables near to the terminations shall also be measured and paid for. However, such looping shall not exceed 2 RMT per termination. No payment shall be made for left out and installed cut cable pieces. The rates quoted for underground cable laying shall include excavation charges, sand cushioning, standard burned brick protection, refilling, consolidating etc., The rates for cable termination works shall include the costs of copper / aluminium termination sockets of suitable type, brass single compression cable glands, copper earth clamps for glands, taping, crimping, yellow pasting, all labour charges etc., The payment for cable trays shall be effected based on the linear measurement of the cable trays of different sizes. The cost shall be inclusive of basic cable tray, suspenders and labour for tray fitting, fabrication and erection.

18.8 STRUCTURAL SUPPORTS

Structural supports like rods, clamps, bolts & nuts, etc for pipes and ducts shall be considered as part of pipe and ducts hence no separate payment will be made. Rates shall be inclusive of hoisting, cutting, jointing, welding, cutting of holes and chases in walls, slabs or floors, painting supports and other items as described in specifications, drawings and bill of quantities or as required at site by Engineer in Charge. The MS supports like plate, channels, angles, etc shall be measured separately as described in BOQ.

19. TESTING AND COMMISSIONING**19.1 SCOPE**

The following quality assurance, inspection, testing and commissioning procedures shall be required to be carried out upon award of work.

- Provide quality assurance program (QAP), works quality assurance program (WQAP), field quality assurance program (FQAP) and quality plan.
- Tests at manufacturer's works.
- Perform site tests and commissioning.

19.2 SUBMITTALS

- After award of work following information shall be submitted.
- Quality Assurance Program (QAP)
- Works Quality Assurance programme (WQAP)
- Field Quality Assurance Programme (FQAP)
- For inspection and testing, submit inspection and testing procedures, programme, and record sheets applicable at each hold point.
- After completion of testing, submit test records, packaging, transportation and storage instructions and methods.
- For site installation and commissioning, submit installation methods or procedures, notification and procedures for pre-commissioning and commissioning.
- After commissioning, submit site test records, as-built drawings, manufacturer's operation maintenance manuals and list of recommended spares and tools.

19.3 QUALITY ASSURANCE CONCEPT AND CONTROL

- Minimum requirements for establishing and implementing a quality assurance programme shall be applied to all aspects of the work necessary for carrying out the contract. Quality assurance shall extend to material parts, components, systems and services as a means of obtaining and sustaining the reliability of critical items, operating performance, maintenance and safety.
- Acceptance of the Tenderer's quality assurance programme does not relieve the Tenderer's obligation to comply with the requirement of the contract document. If the programme is found to be ineffective, then the Client / Consultant's site representative reserves the right to request for necessary revisions of the programme.
- The Tenderer is required to produce readily identifiable documentary evidence covering the extent and details of both his own and his sub tenderer's quality assurances system as follows:
 - Quality Assurance Program (QAP)
 - Works Quality Assurance programme (WQAP)
 - Field Quality Assurance Programme (FQAP)
 - Quality Plan.
- These documents shall be prepared separately and submitted to the Client / Consultant's site representative at the time of starting the work.
- Quality Plan and Manual shall be prepared by the Tenderer for all items and services to be supplied, after the contract has been placed, but before commencement of fabrication, and shall be subject to evaluation and acceptance by the Client / Consultant's site representative before start of work.

19.4 QUALITY ASSURANCE MANUAL (QAM)

- The QAM shall be a general comprehensive document outlining the Tenderer's basic organization, policies and procedures. The information to be given in the QAM shall include but not limited to:
 - Quality Policy.

- Quality Assurance Programme
- Organisation Structure showing inter relationships.
- Functional responsibilities and levels of authority.
- Lines of communication.
- Customer relations.
- Laboratory Facilities.

19.5 WORKS QUALITY ASSURANCE PROGRAMME (WQAP)

- The WQAP shall identify the Tenderer's Quality Assurance Programme at works applicable throughout all phases of Contract performance, including design, procurement, manufacture, inspection and testing. It shall identify each of the programme elements to be designed, developed, executed and maintained by the Tenderer for the purpose of ensuring that all supplies and services comply with these specifications.
- The information to be given under this programme shall include but not limited to:
 - i. Organisation and Responsibility.
 - ii. Contract Review.
 - iii. Design and Document Control.
 - iv. Procurement Control.
 - v. Production Control.
 - vi. Control on Sub-tenderers.
 - vii. In-process Quality Control and Traceability.
 - viii. Inspection and Testing.
 - ix. Control of Non-conformances.
 - x. Corrective Action.
 - xi. Control of Inspection, Measuring and Test Equipment.
 - xii. Handling, Storage, Packaging and Delivery.
 - xiii. Records.
 - xiv. Quality Audits.

- xv. After - Sales Servicing.

19.6 FIELD QUALITY ASSURANCE PROGRAMME (FQAP)

- This programme shall identify the Tenderer's Quality Assurance Programme at site applicable throughout site construction, erection and commissioning. It is the underlying philosophy that the quality built into the product at works shall be maintained throughout the construction and commissioning stages.
- While, in principle, the FQAP shall include the items discussed in WQAP, it shall, however, be approached differently to take into account site conditions.
- The FQAP shall include, but not limited to the following information :
 - i. Organisation and responsibility.
 - ii. Control of Drawings and Documentation.
 - iii. Product Checklist.
 - iv. Control and Traceability of Purchased materials and services.
 - v. Receipt Inspection of materials at site.
 - vi. Material Storage Control.
 - vii. Inspection and Examination Procedures.
 - viii. Control of Painting and Insulation Works.
 - ix. Pre-commissioning.
 - x. Commissioning.
 - xi. Control of Non-conformances.
 - xii. Corrective Action.
 - xiii. Control of Inspection, Measuring and Test Equipment.
 - xiv. Records.
 - xv. Completion Documents.
 - xvi. List of recommended spares and tools.
 - xvii. Personal Training.
 - xviii. Servicing during Defects Liability Period

19.7 QUALITY PLAN

- The tenderer shall be required to prepare manufacturing and construction/erection quality plans for all equipment items and services. The quality plan shall also define the involvement of Client / Consultant's site representative in the inspection and test programmes.
- The Quality Plan shall incorporate as appropriate:
- Charts indicating flow of materials, parts and components through manufacturing quality control inspection and test to delivery and erection.
- The charts shall indicate the location of hold points for quality control, inspection and test beyond which manufacture shall not continue until the action required by the hold point is met, and the documentation required is generated.
- The control documents associated with each hold point, i.e. drawings, material, specification, Works Process Schedule (WPS), Process Quality Records (PQR), quality control methods and procedures and acceptance standards.

19.8 SITE QUALITY CONTROL SECTION

- The Tenderer's Quality Control (Q.C.) section shall be headed by an experienced Quality Control Engineer. He shall be assisted by other supervisors. The section shall be an independent one, reporting to the tenderer's Site Manager only on administrative matters, but otherwise under full control by the Tenderer's Corporate Quality System Management.
- The Tenderer's Q.C. Section shall liaise closely with the Client / Consultant's site representative in charge of Quality Assurance/Quality Control, and to whom it shall give fullest cooperation. It is the underlying principle of this contract document that while the Tenderer's Q.C. Engineer implements the Tenderer's Quality Programme, the adequacy and effectiveness of that implementation shall be audited by the Client / Consultant's site representative whose recommendations on improving or maintaining quality shall be acted upon promptly by the Tenderer's Q.C. Section.

19.9 INSPECTION AND TESTING

The contractor shall carry out all performance / acceptance tests to the satisfaction of Client / Project Manager / Consultant's representative at factory as well as on site. All such

performance tests carried out shall be recorded and submitted for approval to the Client / Project Manager / Consultant's representative.

The tests at site shall be performed to indicate freedom from vibration, unbalance, leakage and to establish the designed performance of the equipment. The contractor shall submit the producer for site tests to Client / Project Manager / Consultant's representative for approval.

After the complete installation of Air-conditioning System with ductwork, pipe-work, insulation etc. is completed, these shall be tested as per the applicable codes (unless otherwise specified), to check, and assess the functional performance. These tests to be conducted at site in the presence of Client / Project Manager / Consultant's representative, shall include, but not limited to the following equipments in summer, monsoon and in winter seasons respectively.

Screw chiller factory inspection and test as per IS, BS, ARI & relevant standards.

- Visual inspection.
- Designed Pressure test: - Refrigerant circuit and water circuit of chiller.
- Designed Pressure test: - Condenser
- Refrigerant suction pressure, Refrigerant Discharge pressure and Oil Pressure.
- Brine / chilled water inlet outlet design temperatures.
- Condenser Water inlet outlet design temperatures.
- Electrical Motor (Compressor motor) insulation test, RPM, voltage, current, full load and part load.
- Vibration and Noise level
- Chiller capacity test.
- Condenser capacity test.
- Brine / chilled water and Condenser Water flow rates
- Chiller part loads and full loads test.
- Chiller starting current and full load current test.

- Water Pumps factory inspection and test as per IS, BS & relevant standards.
- Visual inspection.
- Pump MOC inspection and testing.
- Designed capacity test (discharge and head).
- Motor insulation test.
- R.P.M. of Pumps.
- Vibration and Noise level
- Starting current and running current test.
- Pipes and valves factory inspection and test as per IS, BS & relevant standards.
- Visual inspection.
- MOC inspection and testing.
- Designed Pressure tests.
- Thermal and acoustic Insulations factory inspection and test as per IS, BS & relevant standards.
- Visual inspection.
- MOC inspection and testing.
- Designed thermal resistivity.

19.10 TESTS AT MANUFACTURER'S WORKS

- All tests to be performed during manufacture, fabrication and inspection shall be agreed with the Client / Consultant's site representative prior to commencement of the work. The Tenderer shall prepare the details of the schedule and submit these to the Client / Consultant's site representative for approval. It must be ensured that adequate relevant information on the design code/standard employed, the manufacture /fabrication/assembly procedure and the attendant quality control steps proposed are made available to the Client / Consultant's site representative who will mark in the appropriate spaces his intention to attend or waive the invited tests, or inspections. Tenderer shall arrange inspection and factory witness test for screw chiller.
- A minimum of twenty-one days' notice of the readiness of equipment for test or inspection shall be provided to the Client / Consultant's site representative by the Tenderer (whether

the tests be held at the Tenderer's or Sub-tenderer's works). The subject items should remain available for Client / Consultant's site representative inspection and test up to a minimum 10 days beyond the agreed date of witnessing the test. Every facility in respect of access, drawings, instruments and manpower shall be provided by the Tenderer and sub-tenderer to enable the Client / Consultant's site representative to carry out the necessary inspection and testing of the Plant.

- No plant shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, all tests called for have been successfully carried out in the presence of the Client / Consultant's site representative or approved for shipment, or alternatively inspection has been waived.
- Functional electrical, mechanical and hydraulic tests shall be carried out on completed assemblies in the works. The extent of these tests and method of recording the results shall be submitted to, and agreed by, the Client / Consultant's site representative in sufficient time to enable the tests to be satisfactorily witnessed, or if necessary for any changes required to the proposed programme of tests to be agreed.
- The Client / Consultant's site representative reserves the right to visit the Manufacturer's works at any reasonable time during fabrication of equipment and to familiarize himself with the progress made and the quantity of the work to date.
- Within 30 days of completion of any tests, triplicate sets of all principal test records, test certificates and correction and performance curves shall be supplied to the Client / Consultant's site representative.
- These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Client / Consultant's site representative or not. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the Contract reference title.
- When all equipment has been tested, the test certificates from all works and site tests shall be compiled by the Tenderer into volumes and bound in an approved form complete with index and four copies of each volume shall be supplied to Client / Consultant's site representative.
- Stage wise inspection of equipment in factory is waived.

19.11 PERFORMANCE TESTS AT MANUFACTURER'S WORKS

- All equipment may be subjected to routine performance tests at the Manufacturer's Works in accordance with the relevant ANSI, ASME, ASTM, BIS standard including operating tests of complete assemblies to ensure correct operation of apparatus and components.
- Pumps, fans, compressor, and other rotating equipment shall be given full load tests, and run to 15% overspeed for 5 min to check vibration. Main and auxiliary gear boxes shall be subjected to shock load tests and a six-hour endurance run at rated speed and maximum torque.
- The Tenderer shall submit single line diagrams including the layout of the Plant together with the location of test instrumentation and the principal dimensions of the layout. All calculations to derive performance data shall be made strictly in accordance with format given in the approved standards. Any alterations or deviations from the approved standard test layout or formulae shall be subjected to the prior approval of the Client / Consultant's site Representative.
- The performance test shall be conducted over the full operating range of the pump to a closed valve condition and a minimum of five measurement points covering the full range shall be taken. Curves indicating Quantity vs. Head, Quantity vs. Power absorbed, and Quantity vs. Pump efficiency shall be provided. In addition a curve of the NPSH required vs. Quantity shall be provided except when the suction conditions do not require this test. Any proposal for the omission of this test shall be to the approval of the Client / Consultant's site representative.
- On completion of the tests the Tenderer shall submit a report showing the test results obtained together with the curves corrected to the site operating conditions.

20. TESTING, ADJUSTING AND BALANCING**20.1 SCOPE**

- Testing, adjusting and balancing of heating, ventilating and air-conditioning systems at site.
- Testing, adjusting and balancing of HVAC Hydronic system at site.
- Testing, adjusting and balancing of exhaust system at site.

Comply with current editions of all applicable practices, codes, methods of standards prepared by technical societies and associations including:

ASHRAE : HVAC Application.

SMACNA : Manual for the Balancing and Adjustment of air distribution system.

20.2 PERFORMANCE

- Verify design conformity.
- Establish fluid flow rates, volumes and operating pressures.
- Take electrical power readings for each motor.
- Establish operating sound and vibration levels.
- Adjust and balance to design parameters.
- Record and report results as per the formats specified.

20.3 DEFINITIONS

- Test : To determine quantitative performance of equipment.
- Adjust : To regulate for specified fluid flow rates and air patterns at terminal equipment (e.g. reduce fan speed, throttling etc.)
- Balance : To proportion within distribution system (sub mains, branches and terminals) in accordance with design quantities.

20.4 TESTING, ADJUSTING AND BALANCING (TAB) PROCEDURES

The following procedures shall be directly followed in TAB of the total system. Before commencement of each one of the TAB procedure explained hereunder, the contractor shall intimate the Client / Consultant's site representative about his readiness to conduct the TAB procedures in the format given in these specifications.

20.5 DESCRIPTION OF SYSTEM AND REQUIREMENTS

Adjust and balance the following system to provide most energy efficient operation compatible with selected operating conditions.

- All supply, return and outside air systems.
- All exhaust air systems.
- All brine / chilled water systems.
- All cooling tower (condenser) water systems.
- Emergency purge systems.

20.6 AIR SYSTEMS**Air Handlers Performance**

The TAB procedure shall establish the right selection and performance of the AHUs with the following results:

- Air-IN DB and WB temperature.
- Air-OUT DB and WB temperature.
- Dew point air leaving.
- Sensible heat flow.
- Latent heat flow.
- Sensible heat factor.

- Fan air volume.
- Fan air outlet velocity.
- Fan static pressure.
- Fan power consumption.
- Fan speed.

Air distribution

Both supply and return air distribution for each AHU and for areas served by the AHU shall be determined and adjusted as necessary to provide design air quantities. It shall cover balancing of air through main and branch ducts utilizing telescoping probes of Electronic Rotating Vane Anemometers (Air Flow Hood with type)

The Preparatory Work

To conduct the above test, following preparatory works are required to be carried out including the availability of approved for construction shop drawings and submittals:

- All outside air intake return air and exhaust air dampers are in proper position.
- All system volume dampers and fire dampers are in full open position.
- All access doors are installed & are air tight.
- Grilles are installed & dampers are fully open.
- Provision and accessibility of usage of TAB instruments for traverse measurements are available.
- All windows, doors are in position.
- Duct system is of proper construction and is equipped with turning vanes and joints are sealed.

20.7 HYDRONIC SYSTEM BALANCING

- The Hydronic system shall involve the checking and balancing of all water pumps, piping network (main & branches), the heat exchange equipment like cooling and heating coils, condensers and chillers and cooling towers in order to provide design water flows.
- The essential preparation work, must be done by the HVAC contractor prior to actual testing, adjusting and balancing of HVAC system and ensure following:
- Availability of co-ordinated drawings and approved submittals and system sketch with design water flows specified thereon.
- Hydronic system is free of leaks, is hydrostatically tested and is thoroughly cleaned, flushed and refilled.
- Hydronic system is vented.
- The contractor or his nominated TAB (Testing, Adjusting & Balancing) agency shall confirm completion of the basic procedures and prepare check lists for readiness of system balance.
- Check pumps operation for proper rotation and motor current drawn etc.
- Confirm that provisions for TAB measurements (Temperature, pressure and flow measurements) have been made.
- Open all shut-off valves and automatic control valves to provide full flow through coils. Set all balancing valves in the preset position, if these values are known. If not, shut all riser balancing valves except the one intended to be balanced first.

Balancing work for both Brine / chilled water System and Condenser Water System shall be carried out in a professional manner and test reports in the specified format shall be prepared and presented to the Client / Consultant's site representative for approval.

20.8 READINESS FOR COMMENCEMENT OF TAB

Before starting of any of the tests, the readiness to do so should be recorded as per the prescribed check list.

TAB INSTRUMENTS

- Air Measuring Instruments
 - For measuring DB and WB temperature, RH and dew point, microprocessor based TSI USA make VelociCalc Plus Meter, Model 8386, or equivalent shall be used. This instrument shall be capable of calculating the sensible, latent total heat flows, sensible heat factor and give printouts at site and have data logging/downloading facility.
 - For measuring Air velocity, DB temperature and Air volume, TSI USA make VelociCalc meter model 8345 or equivalent shall be used. It shall be able to provide instant print out of recorded Air volume readings.
 - Pitot tube.
 - Electronic Rotary Vane Anemometer TSI make or equivalent.
 - Accubalance Flow Measuring Hood TSI make or equivalent.
- [All above instruments shall have NIST testification (US Institute of Science and Technology) Calibration Certificate]
- Hydronic Measuring Instruments - For measurement of water flow, differential pressure and temperature, CBI Measuring instrument (Tour & Anderson AB Sweden or equivalent) shall be used. The instrument shall have a built-in microcomputer capable of giving readings for pressure differential, flow rate and temperature.
- Rotation Measuring Instrument - Electronic Digital Tachometer.
- Temperature & RH Measuring Instrument - TSI VelociCalc model 8386 and VelociCalc model 8345 or equivalent.
- Electrical Measuring Devices - Clamp on Volt ammeter & Continuity Meter.
- Vibration and Noise Levels
- Vibration and alignment field measurements shall be taken for each circulating water pump, water chilling unit, air handling unit and fan driven by a motor over 10 HP. Readings shall include shaft alignment, equipment vibration, bearing housing vibration, and other test as directed by the Client / Consultant's site representative. Sound level readings shall be taken at ten (10) locations in the building as selected by the Client / Consultant's site representative. The readings shall be taken on an Octave Band analyzer in a manner acceptable to him. The contractor shall submit test equipment data and reporting forms for

review. In order to reduce the ambient noise level the readings shall be taken at night. All tests shall be performed in the presence of Client / Consultant's site representative.

TABLE OF CONTENTS

1. PUMPS.....	2
2. CHILLER	4
3. AHU	10

1. PUMPS

Sr No.	DESCRIPTION	UNIT/PARTICULARS	VENDOR SPECIFICATION
1	Make		
2	Model		
3	Origin		
4	Design Flow rate	GPM	
5	Head	m	
6	Pump Efficiency	%	
7	Motor Efficiency at duty point	%	
8	Motor Rating	kW	
9	Rated Speed	rpm	
10	Motor Efficiency type	IE-4	
11	Motor IP and Insulation Class		
12	Material of construction as per specification - indicate deviations if any		
13	Impeller make & type		
14	Weatherproof construction for pump and motor		
15	Is Logic Control Panel for Variable Pumping System included, wherever specified		
16	Is logic control panel compatible to hook up to CPM / BMS? If so necessary hardware & software included in scope of work? What is the protocol considered for		

	Integration? Is it suitable for Outdoor Installation		
17	Shipping Weight	kg	
18	Operating Weight	kg	

2. CHILLER

Sr No.	DESCRIPTION	UNIT/PARTICULARS	VENDOR SPECIFICATION
	GENERAL:		
1	Make & Model		
2	Country of Origin		
3	Refrigerant Used		
4	Capacity - TR @ Tender Condition		
5	Chiller		
6	CHW in/out	12.2 deg C / 6.66 deg C	
7	CDW in/out:	30.5 deg C / 36.05 deg C	
8	Fouling factor:		
9	Chiller side		
10	Condenser side		
11	Capacity TR	@ ARI Condition	
12	COP and kW / TR	@ Tender Condition	
13	COP and kW / TR	@ ARI Condition	
14	No. of Compressors / Machine		
15	No. of Condensers / Machine		
16	No. of Chillers / Machine		
17	Overall dimensions (mm x mm x mm)		

18	Operating Weight	Kg	
19	Shipping Weight	Kg	
20	Overall IPLV	@ ARI Condition	
21	Part Load Characteristics	ARI Condition	
22	Load	1	
23	Load	0.75	
24	Load	0.5	
25	Load	0.25	
26	Overall NPLV	@ Tender condition	
27	Part Load Characteristics	Tender condition	
28	Load	1	
29	Load	0.75	
30	Load	0.5	
31	Load	0.25	
32	Minimum clearance required from adjacent Structures	m	
33	Minimum clearance required between two Machines	m	
34	Whether any platform or pedestal required for Installation? If so, furnish details.		
35	Noise level at a distance of 1 m from the machine at intervals of 1 m along the perimeter - db		
36	Noise level when all the machines are working – db		

37	Finish details i.e., hot dip galvanized, Corrosion resistant etc.		
38	Whether factory fabricated?		
39	Is necessary Integrator with necessary hardware & software considered along with chiller package for integrating with CPM / third party BMS System		
	COMPRESSOR – MOTOR UNIT		
1	Make & Model		
2	Compressor Type		
3	a. Whether hermetic or semi-hermetic?		
4	b. Whether Vertical or Horizontal Cylinder?		
5	Capacity at operating conditions	TR	
6	Total Power Consumption	KW	
7	Drive losses	KW	
8	Motor efficiency	%	
9	In put KW		
10	KW / TR		
11	Unloading Steps		
12	Capacity Control Type		
13	Electrical Characteristics		
14	Insulation Class		
15	Protection Class		

16	Motor Type		
17	Full current	amps.	
18	Starting current	amps.	
19	Starter type		
20	Type and method of oil cooling		
	CONDENSER:		
1	Type of condenser	DX or Flooded	
2	Water flow rate	gpm	
3	Heat Rejection Capacity	BTU/Hr	
4	Entering Water Temperature	Deg C	
5	Leaving Water Temperature	Deg C	
6	Fouling Factor		
7	Pressure Drop		
8	Material of Tube		
9	Tube OD	mm	
10	No of Passes		
11	Material of fin		
12	Test pressure	Kg	
	CHILLER:		
1	Type of chiller	DX or Flooded	

2	Shell OD	mm	
3	Overall length	mm	
4	Overall weight	Kg	
5	Number of tubes		
6	Tube OD	mm	
7	Nature of tubes (whether integrally finned or Whether tubes carry inserts)		
8	Length of tube between tube sheets		
9	Material of tube		
10	Material of shell		
11	Water side surface area	sqm	
12	Refrigerant side surface area	sqm	
13	Minimum operating charge of refrigerant	Kg	
14	Water Flow rate	lpm	
15	Leaving water temperature	Deg C	
16	Entering Water temperature	Deg C	
17	Refrigerant temperature	Deg C	
18	Leaving temperature difference	Deg C	
19	No. of passes		
20	Tube velocity	mps	
21	Pressure drop	Kg/sqcm	

	CONTROL PANEL		
1	How Many Chillers can it Handle?		
2	Is all the parameters, which are possible to view in the graphic screen mounted on chiller, are possible to view & modify from remote location?		
3	If yes, has it been included in the offer?		
4	Is necessary hardware & software required for integration included in the offer?		
	UNIT MOUNTED STARTER		
1	Is unit mounted star delta starters included in the offer?		
2	Is additional features like circuit breakers and mechanical non-fused disconnects are included in the offer?		
3	ARI / Eurovent Certification		

3. AHU

Sr No.	DESCRIPTION	UNIT/PARTICULARS	VENDOR SPECIFICATION
	General		
1	Manufacturers name		
2	Model No		
3	Capacity	CFM	
	Frame		
1	Material of frame		
2	Describe frame - panel joints		
	Panel Insulation		
1	Material		
2	Panel thickness	mm	
3	Inner skin thickness and coating	mm & GSM	
4	Outer skin thickness and coating		
	FAN AND FAN MOTOR :		
1	Make		
2	Type of fan		
3	Type of blades (i.e., whether forward curved or backward curved or aerofoil section)		
4	Air Delivery	cfm	
5	External Static Pressure	mm	

6	Total Static Pressure - mm wg (to be considered at dirty condition)		
7	Maximum static pressure capability - mm wg		
8	Speed	rpm	
9	Type of motor		
10	Motor speed	rpm	
11	Motor efficiency		
12	Type of starter		
13	Fan Noise Level?		
14	Whether impellor and shaft dynamically (and statically) balanced?		
15	Vibration level		
	FILTER SECTION :		
1	Overall dimensions	mm x mm x mm	
2	Type of filter		
3	Media used		
4	Efficiency of filter (State the test method)		
5	Manufacturer's name		
6	Resistance of filter when clean-mm wg		
7	Maximum resistance of filter - mm wg		
8	Dust Holding Capacity (Per & Fine Filter) – gms		
9	Is the media cleanable?		

10	Is one set of commissioning filters considered in the Quote?		
	COOLING COIL		
1	Please specify the type of Coils considered in the scope?		
2	Material of Construction for Coil / Tubes		
3	Material of Construction for Fins		
4	Is special quoting specified in the Specs for Fins considered in the Scope		
5	Is Moisture eliminator considered after coil section?		
6	What is the material of construction for moisture eliminator		
7	No of Rows		
8	Coil Selection Attached?		
	ENERGY RECOVERY WHEEL		
	(wherever applicable)		
1	Make & Type		
2	Sensible recovery efficiency	%	
3	Latent recovery efficiency	%	
4	Purge Section details		
5	Wheel Motor rating		
6	Air leak losses make up details		
	SAFETY FEATURES		
1	Is safety switch (fan limit switch) considered in AHU?		

	Physical properties		
1	Overall dimensions	mm x mm x mm	
2	Overall weight	kg	
3	Is AHU suitable for Outdoor Installation? If so Weatherproof Canopy is Considered (Please refer where ever it is called)?		
	OTHERS		
1	Is Mixing boxes considered in the scope		
2	Is SA / RA damper included in the scope		
3	Is Canvass connection at outlet included		

TECHNICAL SPECIFICATIONS FOR FIRE PROTECTION SYSTEM WORKS

CONTENTS

CONTENTS.....	2
1.0 GENERAL	3
2.0 SCOPE OF WORK & SPECIFIC REQUIREMENT – FIRE PROTECTION SYSTEM. EQUIPMENT & SERVICES TO BE PROVIDED BY THE CONTRACTOR	9
3.0 TENDER DRAWINGS, DRAWINGS FOR APPROVAL.	11
4.0 SPECIFIC REQUIREMENTS / INSTRUCTION TO CONTRACTORS	11
5.0 SPECIFICATION – FIRE PROTECTION SYSTEM	13
6.0 PIPES WORK.....	26
7.0 VALVES	32
8.0 INSTRUMENTATION	34
9.0 HYDRANT ACCESSORIES	34
10.0 AUTOMATIC SPRINKLER SYSTEM.....	37
11.0 CLEAN AGENT GAS BASED FIRE SUPPRESSION SYSTEM.....	39
12.0 FIRE EXTINGUISHER SYSTEM	45
13.0 EQUIPMENT & SERVICES TO BE PROVIDED BY THE CONTRACTOR FOR INSTRUMENTATION & CONTROL SYSTEM FOR FIRE PROTECTION SYSTEM	50
14.0 FIRE STOP SEALANT	55
15.0 ELECTRICAL	55
16.0 CHAIN BLOCK PULLEY.....	55
17.0 TESTING OF THE SYSTEM	61
18.0 COMMISSIONING OF SYSTEM:	62
19.0 DATA TO BE FURNISHED BY THE CONTRACTOR AFTER THE AWARD OF CONTRACT AND BEFORE INSTALLATION.....	66
20.0 LIST OF APPROVED MAKES FOR FIRE PROTECTION SYSTEM EQUIPMENTS/ MATERIALS NOTE:	68

1.0 GENERAL

The Contractor's scope of work covers supply, installation, commissioning and testing of the complete "Supply, Installation, Testing & Commissioning of Fire Protection System" works as specified.

The work shall be executed as per CPWD's general specification for Electrical Works, Part-I-2013, Part-V-2020, DSR, AOR for Wet Riser and Sprinkler System-2022, Delhi Schedule of Rates (E and M)-2022, Civil DAR 2022, TN PWD SOR, TWAD General Conditions of Contract, Special Condition of Contracts, Schedule of Work, Drawings and other documents connected with the work.

1.1 IMPORTANT NOTE:

The Contractor shall be fully responsible for meeting all the statutory obligations & local inspectorates wherever applicable to the works carried out by them. The Contractor should prepare all working drawings and obtain approval of competent authorities and also have the equipment and installation inspected and got approved. All official fees will be paid by Employer directly against demand in writing from the appropriate authority and all other expenses for submission and approval of the various and relevant statutory / bodies shall be embodied in the tender prices.

Performing and submitting Hydraulic calculations in PIPENET Software shall be in the scope of contractor.

Manufacturers' instructions regarding installation, connections and commissioning shall be strictly followed.

Contractor shall provide necessary test certificates, type test certificates, performance curves and NPSH curves of the pumps from the manufacturer prior to procurement and get it approved from the PMC/Employer. The contractor shall provide facilities to the PMC/Employer for inspection of equipment during manufacturing and also to witness various tests at the manufacturer's works without any cost to the PMC/Employer

1.2 INTRODUCTION

The Fire protection systems have been categorized into the following types:

Internal Fire Hydrant System: - The Internal Fire Hydrant System shall be provided throughout the building & may be operated to control and extinguish fires in incipient or advanced stages.

External Fire Hydrant System: - The External hydrants shall be provided around building near to the face of building.

Automatic Sprinkler System: -Sprinkler system shall be provided for detection of Fires and Automatic actuation in the region of fire, thus preventing its spread.

Clean Agent based Gas Fire Suppression System: - Clean Agent system will be designed as per NFPA 2001:2022 and will be provided to critical room i.e. IBMS room and server room.

Portable Fire Extinguishers: - The Portable Fire Extinguishers shall be located in the facilities / buildings & these shall be used for extinguishing small Fires.

1.3 CODES AND STANDARDS

Following codes and standards have been referred.

- In case of information not being clear or not available in NBC, IS & NFPA shall be followed as applicable.
- All equipment, supply, erection, testing and commissioning shall comply with the requirements of all latest Codes and Standards issued by the Bureau of Indian Standards.

Codes	Code Description
TNFRS	Tamil Nadu Fire & Rescue Services
NBC 2016 Part 4	National Building Code
IS: 13039: 2014 Reaffirmed 2019	External hydrant system – Provision & maintenance – Code of practice
IS: 15105: 2021	Design & Installation of Fixed Automatic Sprinkler Fire Extinguishing System – Code of practice
IS: 15325: 2003 Reaffirmed 2013	Design and installation of fixed automatic High and Medium Velocity Water Spray System– Code of practice
IS: 3844:1989 (Reaffirmed 2020)	Code of practice for installation & maintenance of internal fire hydrants and hose reels on premises
IS 5290 : 1993 (Reaffirmed 2018)	Specifications for hydrant landing valves.
IS 1239 : Part 1 : 2004 (Reaffirmed 2019)	Specification for Steel Tubes, Tubular and wrought steel fittings.
IS 1239 : Part 2 : 2011 (Reaffirmed 2021)	Specification for Steel Tubes, Tubular and other steel fittings.
IS 3589 : 2001 (Reaffirmed 2022)	Steel pipes for water and Sewage (168.3 to 2540 mm Outside diameter) –Specification.
IS 10221 : 2008 (Reaffirmed 2021)	Code of practice for coating and wrapping of underground mild steel pipelines.
NFPA 13: 2019	Standard for the Installation of Sprinkler Systems
NFPA 14: 2019	Standards for Installation of Standpipe, Private

Codes	Code Description
	Hydrant & Hose System
NFPA 2001:2022	Standard on Clean Agent Fire Extinguishing Systems

1.4 SYSTEM DESCRIPTION

1.4.1 Fire water tank

Based on NBC 2016, an underground Fire water tank of **2,00,000 litres** capacity has been envisaged for sprinkler and hydrant system. The fire water storage tank is divided into two equal compartments i.e., **1,00,000 litres x 2 no.** for Hydrant and Sprinkler System.

1.4.2 Overhead Water Storage Tank

The capacity and number of overhead water tank is **20,000 litres X 1nos.**

1.4.3 Hydrant System

Fire Hydrant System has been envisaged throughout the building to control and extinguish fires in incipient or advanced stages.

- a. The hydrant system consists of :
 - Internal hydrant valves with hoses, hose reels, nozzle and branch are placed in fire shaft with fire shaft door.
 - Fire water piping with MS 'C' Class pipe with necessary valves.
 - Pumps comprising – One motor driven pump of capacity 2850 lpm & 120 mwc head, Two standby diesel engine driven pump of capacity 2850 lpm & 120 mwc head (For both hydrant and sprinkler system) and One line pressurization jockey pump of capacity 180 lpm & 120 mwc head .
 - 01 nos. of Booster Pump of 900 lpm capacity & 40 mwc head has been provided to ensure adequate pressure at outlet of hydrant valves situated on the top floors.
 - Necessary panel, cables, and instrumentation.
- b. Internal hydrant main pipe connected to ring main routed at basement ceiling level for wet riser pipe tapping.
- c. Fire brigade inlet connection shall be provided to enable fire brigade vehicles to pump in water into the hydrant system / fire underground tank.
- d. As per IS 13039, clause 4.12, the external hydrants (single outlet hydrant valve) are planned at the distance of 45m apart and within 2m -15m from the building. For each external hydrant, a hose box with two nos. Hoses with coupling, each of 15m length, will be provided. (Note: Hydrant spacing will be changed as per provisional FIRE NOC copy).
- e. Draw out connection shall be provided to enable the fire brigade teams to draw water from the fire water storage tanks in case of any eventuality.

1.4.4 Automatic Wet Sprinkler System

Automatic Wet Sprinkler system has been envisaged for detection of Fires and Automatic actuation in the region of fire, thus preventing its spread.

- a. The sprinkler system consists of
- Sprinklers
 - Alarm valves
 - Underground and above ground fire water piping of MS 'C' Class pipe with necessary components (i.e. Isolation Valve, test and drain connection, flow switch etc).
 - Pumps comprising – One motor driven pump of capacity 2850 lpm & 120 mwc head, and One line pressurization jockey pump of capacity 180 lpm & 120 mwc head.
 - Necessary Panel, cables and instrumentation.
- b. Concealed sprinklers have been used in all spaces except Utility & Service areas.
- c. Sprinkler drain riser pipe shall be connected to catch basin located in the basement.
- d. A flow switch will be installed on downstream of alarm valve to relay annunciation in FDAS panel of building if any of the sprinklers is activated.
- e. Sprinklers will be provided within 600mm from glass façade in line with the NBC 2016 – Clause 3.4.10.2.
- f. The sprinkler are Standard response, quartzoid bulb rating for following areas

Sr. No.	Type of area	Type of Sprinkler	Remarks
1	Above false ceiling	Upright sprinkler, 68° deg C	
2	Below false ceiling	Pendant sprinkler, 68° deg C	Adjustable royal flush Concealed
3	Façade Glazing	Side wall sprinkler, 68° deg C	
4	Refuge area	Pendant sprinkler, 68° deg C	
5	Double Height Lobby	Pendant sprinkler, 68° deg C	Adjustable royal flush Concealed
6	Kitchen	Pendant sprinkler, 93° deg C	Preparation area

1.4.5 Clean Agent based Fire Suppression System

- Clean Agent system has been envisaged as per NFPA 2001:2022 to cater to critical rooms i.e. IBMS Server room.
- Clean agent-based fire suppression system for Server room has been envisaged & designed as per NFPA 2001-2022 Edition requirement.
- Clean agent-based Fire suppression system consists of a bank of Clean agent cylinders connected to a piping network which will have open nozzles. This system shall be activated automatically on receiving command from detection system.
- 100% online Stand-by cylinders of clean agent has been considered for restoring the area protection after discharge of main bank of cylinders.
- The agent released would not cause any damage to the high value electronic equipment in the room.
- Clean agent system will be UL Listed / FM / Vds approved.

1.4.6 Fire Extinguishers System

Fire Extinguishers shall be located in the facilities / buildings & these shall be used for extinguishing small fires. Portable fire extinguishers have been envisaged as per IS: 2190 (2010) guidelines to put-off small fires and shall be used in the incipient stage of fire thus avoiding major losses.

The location of portable fire extinguishers shall be finalised to suit the building layout & following considerations:

- a. Easily accessible. (Within 10 to 15 mtr)
- b. Nearness to doors, windows, emergency doors and escape routes.
- c. Covering the area uniformly.
- d. Safe distance from application area.
- e. Fire Extinguishers shall be mounted wall /Floor as per the aesthetic requirement.

1.4.7 BRIEF SPECIFICATION OF MAJOR COMPONENTS

Sl. No.	Name	MOC/Type/Standard
I.	Motor driven Main pumps	Horizontal type, multistage, centrifugal, split casing pump of cast iron body & bronze impeller with stainless steel shaft, mechanical seal conforming to IS 1520
(ii)	Diesel Engine driven standby pumps	Horizontal type, multistage, centrifugal, split casing pump of cast iron body & bronze impeller with stainless steel shaft, mechanical seal conforming to IS 1520
(iii)	Jockey pumps	Vertical type, multistage, centrifugal pump of cast iron body and bronze impeller with stainless steel shaft, mechanical seal conforming to IS: 1520.
(iv)	Booster pumps	Horizontal Monoblock pump of cast iron body, bronze impeller,
(v)	Pipes up to and including 150mm NB	IS:1239 Part-1 (Heavy), M.S / Galvanized
(vi)	Pipes of 200mm NB and above	IS:3589, M.S / Galvanized
(vii)	Pipe Fittings (15NB to 50NB)	GI/MS Fittings(40 mm dia. and below shall be Forged Steel fittings as per ASTM A 105 3000CL, end connection Socket welded as per ASME B16.11. & one side socket weld and other side threaded as per NPT for fittings used for sprinklers

Sl. No.	Name	MOC/Type/Standard
(ix)	Pipe Fittings (50 NB & Above)	GI/MS Fittings of 50 mm dia & above shall be as per ASTM A 234 Gr. WPB all fittings shall be BW seamless fittings type as per specifications.
(x)	Isolation Gate valves	Non rising spindle, Bronze/ Gun metal seat, ISI marked conforming to IS 14846
(xi)	Single Headed Hydrant Valves	63mm SS 304 ISI marked oblique pattern conforming to IS: 5290 Type A.
(xii)	Fire Hoses (Fire shaft door will be in Architectural Specification).	63 mm. Reinforced Rubber-lined conforming to IS:636 Type A with SS 304 instantaneous couplings duly bound at either end and.
(xiii)	Branch Pipes with Nozzles	63mm SS 304 ISI marked short pattern conforming to IS: 903.
(xiv)	Hose Cabinets	Fabricated out of 16 SWG G.I CRCA As Per IS 277 & Base Metal Conforming To IS 513, with 3mm thick glass fronted doors suitable for holding Two nos. fire hoses, one branch pipe with nozzle and one no. nozzle spanner.
(xv)	Hose Reels	As per IS:884 and to be provided with 30m long x 20mm dia. rubber hose pipe and SS-304 shut-off nozzle.
(xvi)	Sprinkler Alarm Valve, Nozzles, Drain-cum-Test valves & Accessories	UL Listed / FM approved
(xvii)	Portable Fire Extinguishers	Conforming to IS :15683
(xviii)	External Hydrant pipes	Centrifugally cast (spun) Ductile Iron pipe with tyton jointed class "K9" confirming to IS 8329 with class K12

1.4.8 **PRESSURE RATING**

Following pressure rating criteria to be followed while selecting the pipes, fittings ,valve and accessories.

Sr.No.	Description	Pressure Rating
1	Pump room and basement -1 Floor	PN 20
2	Ground Floor and Above Floor	PN 16

2.0 SCOPE OF WORK & SPECIFIC REQUIREMENT – FIRE PROTECTION SYSTEM. EQUIPMENT & SERVICES TO BE PROVIDED BY THE CONTRACTOR

2.1 This specification covers the general requirements of design, preparation of detailed drawings, manufacture, supply of material, testing, inspection at CONTRACTOR'S works, packing, forwarding, transportation, transit insurance, delivery at site, unloading and handling at site from storage area to workplace, erection / installation, testing, commissioning at site and carrying out performance / acceptance tests of the equipment, warranty certificate as per Client requirement, materials and services as per enclosed data sheets and other documents for fire protection system (FPS).

2.2 The scope of work is as listed below:

- a. This package is for provision of Fire Protection System for TIDEL Park at Madurai.
- b. Supply, Installation, Testing, Commissioning & handing over of Pump house which shall include pump sets with Electrical Panel, controller, cabling, piping, fittings, valves and ancillary equipment as per technical specifications, schedule of quantities and drawings.
- c. Supply, Installation, Testing, Commissioning & handing over of Sprinkler system, Internal & External Hydrant system and Portable Fire Extinguishers shall be provided for all floor as per technical specifications, schedule of quantities and drawings.
- d. Design, Supply, Installation, Testing, Commissioning & handing over of clean agent based fire suppression system
- e. Excavation upto required depth – manual/ through machinery and backfilling including compaction and carting away of excess soil for laying underground pipes.
- f. Proper protection of underground pipe with 100mm soft sand. All supports for underground and above ground pipes shall be done by contractor.
- g. Making holes/openings in walls, providing sleeves and sealing them back to the satisfaction of PMC/Employer
- h. Automatic pump starting system with all accessories, wiring and connections and pressure switches.
- i. Pressure gauges with syphon pipe shall be with half coupling tapping, isolation valves and piping, bleed, block valves etc complete.
- j. Test certificates, UL/FM/VDS approved documents, Operating & maintenance Manuals of all equipment's / fittings, Warranty/Guarantee certificate duly signed and certified by Contractor.
- k. RCC Sleepers / Thrust blocks / Anchor for underground pipe wherever required, shall be supplied and constructed by the CONTRACTOR.
- l. Flushing connections of 50 mm dia should be provided for sprinkler cross mains at the suitable locations zone wise.
- m. An inspector's test connection shall be provided at the end of the hydraulically most remote branch line for each system at operate able location and drain lines shall be extended up to nearest main drain. This outlet shall not be concealed.
- n. Supply, Installation of Structural / Hanger supports.

- o. At least 10 percent welded joints should be radiography for above ground pipe & 100 percent welded joints radiography for underground piping. If desires to have testing at doubtful location, it shall be responsibility of contractor to carry out without any extra cost.
 - p. All welding methods and qualifications for joining sprinkler system piping shall comply with the minimum requirements of the latest version of ANSI/AWS B2.1, Specification for Welding Procedure and Performance Qualification, or equivalent method.
 - q. Sprinkler shall be fitted below obstruction (Ducts) separate sprinkler heads below obstructions as per following condition shall be provided in areas if the obstruction of width more than 600mm.
 - Rectangular and more than 0.8 m wide and less than 150 mm from the adjacent walls or partitions.
 - Circular and more than 1 m in diameter and less than 150 mm from the adjacent walls or partitions.
 - Rectangular and more than 1 m in width.
 - Circular and more than 1 m in diameter.
 - r. Installation, testing and commissioning of sprinkler system components i.e. sprinkler, sprinkler rosettes plate, rigid pipe, flexible drop pipe, fittings, supports, valves, pressure gauge etc shall be as per IS 15105: 2021.
 - s. Any other point not listed above but required for successful completion of the fire protection system shall be in the scope of Contractor.
- 2.3 The design engineering for this package has been done as per Tamil Nadu Fire and Rescue service, National Building Codes of India (NBC) part IV guidelines 2016, general specification for Electrical Works Part-V-2020, Local Fire Authority requirements and schematic/ general layout drawings for fire pump house equipment, hydrant, sprinkler & fire extinguishers have been prepared by the Engineer. However, as part of design engineering, the following shall be in the scope of Contractor:
- a. Contractor to get Fire NOC approval from statutory authorities, including taking out necessary number of prints of drawings, submission to accredited agency, coordinating site visits, making any minor modification in drawings for the purpose, etc.
 - b. Supporting arrangements needed (indoor & outdoor) for the piping, valves and instrumentation, operating platforms / crossovers etc in pump house & all work locations of site
 - c. Hume pipes shall be as per standard practice & as mentioned in technical specifications to be provided wherever road crossings are shown.
 - d. All anchor bolts, nuts, washers and inserts to be embedded in concrete for the equipment and piping.
 - e. The flanges, companion flanges with nuts, bolts & gaskets for nozzles on fire water reservoir shall be in the scope of contractor.
 - f. Performing and submitting Hydraulic calculations in PIPENET Software shall be in the scope of contractor.
- 2.4 Supply and application of painting shall be as per IS:5 for piping, fitting, valves, equipment, fire hose cabinets, structural steel and auxiliary steel for supports. The painting should have warranty upto entire Defect Liability Period. In case of failure the contractor should repaint at their own cost.
- 2.5 Any item which may not have been specifically mentioned herein but are needed to complete the equipment / system shall also be treated as included and the same shall also be furnished and erected, unless otherwise specifically excluded as indicated.

- 2.6 The pump should be tested for benchmark at factory and shall be approved by the Local fire Authority.
- 2.7 Fire Protection System final flushing/ Hydrotesting to be witnessed by PMC/Employer & test results should meet the requirements.
- 2.8 For routing piping, cabling etc. breaking / making of opening in wall along with re-packing or core packing, etc. shall be carried out by Contractor at no extra cost.

3.0 TENDER DRAWINGS, DRAWINGS FOR APPROVAL.

- 3.1 The drawings provided to the Contractor with the tender documents give a general scheme of the system and are not meant to be the working drawings. The contractor shall furnish the shop drawings to be sent to the PMC/Employer, of all the equipment/ layouts after award of the contract and the same shall be approved by the PMC/Employer. No work shall be allowed to be executed without the approved shop drawings.

- i) The successful Contractor/ contractor shall provide detailed pump head and clean agent flow (FK-5-1-12 or Equivalent) calculations.

- ii) Tender Drawings

The drawings appended with the tender documents are intended to show the areas to be conditioned, space allotted for various equipment, tentative cable and pipe routes. The equipment offered shall be suitable for installation in the spaces shown in these drawings.

- iii) Drawings for approval on award of the work

The contractor shall prepare & submit six sets of following drawings and get them approved from the PMC/Employer before the start of the work. The approval of drawings however does not absolve the contractor not to supply the equipment/ materials as per agreement, if there is any contradiction between the approved drawings and agreement.

- a) Layout drawings of the equipment to be installed in various rooms such as fire plant room and other equipment.
- b) Drawings including section, showing the details of erection of entire equipment including their foundations, water basin for the cooling towers etc.
- c) Fire protection system drawings showing the layout of entire piping, dia & length of pipes, valves and isometric drawings showing connections to various equipment.
- d) Electrical wiring diagrams for all electrical equipment and controls including the sizes and capacities of the various cables and equipment,
- e) Dimensioned drawings of all electrical and control panels,
- f) Drawings showing details of supports for pipes, cable trays etc.
- g) Any other drawings relevant to the work.
- h) Making any modifications in the drawings to suit site conditions and get the approval from PMC /Employer.

4.0 SPECIFIC REQUIREMENTS / INSTRUCTION TO CONTRACTORS

- 4.1 All equipment supplied shall have capacities not less than those specified in the data sheets and necessary test certificates shall be furnished in this regard. Approved Makes and type of equipment/ components shall be supplied. The make, type reference of the equipment is subject to PMC/Employer approval.

- 4.2 Grouting of all equipment and supports, supply of grounding material such as cement, sand, necessary form work etc. is Contractor's responsibility.
- 4.3 No Separate payment will be made for necessary structural supports of piping.
- 4.4 The quantities of piping & valves, specialties etc. indicated in Bill of Quantities are indicative for the purpose of Contractor's guidance and shall not be binding to limit the scope of Contractor's work.
- 4.5 Contractor shall note that for piping, quantities of fittings like elbows, reducers, fabricated reducers / mitres, compression fittings, flanges, nipples etc. are not defined. The price for supply, fabrication and erection of necessary fittings shall be included in the unit rates for respective pipe sizes. The rates for flanges, and hardware like bolts, nuts, washers and gaskets shall be included in prices quoted for pipes, equipment, valves and specialties as applicable.
- 4.6 No separate prices are called for painting. Price for supply and application of painting shall be included in the unit prices for piping, valves and equipment, structural steel work as applicable.
- 4.7 Initial inspection at works and final inspection and testing at site shall be carried out as per CPWD General Specification.
- 4.8 All charges for inspection, testing, radiography, dye penetrate testing, flushing, cleaning, hydro/air testing, purging with inert gases, integrity test for inert gas, commissioning including all consumables required for same shall be included in the unit rate for erection of piping/valves/equipment.
- 4.9 Minor civil works like wall opening, chipping of foundation, grouting of foundations shall be carried out at no extra cost.
- 4.10 The CONTRACTOR shall supply and erect all required temporary pipes, fittings, flanges, valves and specialties and hangers and supports for testing and cleaning operations, as a part of the erection scope of contract for each of the systems listed above. The CONTRACTOR shall consider this requirement while quoting unit prices for erection.
- 4.11 The construction of the fire protection system requires all CONTRACTORS to adhere to good daily housekeeping practices. During construction the CONTRACTOR shall every day, keep all work and storage areas used by them free from accumulation of waste materials. Scrap/ rubbish shall be removed from the site to the satisfaction of the client. The CONTRACTOR shall maintain a crew to carry out this function without any additional payment.
- 4.12 The contractor shall prepare and submit to the PMC/EMPLOYER for approval, final piping bill of materials as actually erected for purpose of reconciliation.
- 4.13 The surplus material with the CONTRACTOR for all materials brought by him shall be taken back by the CONTRACTOR except surplus from those materials for which the PMC/EMPLOYER has given, in writing, clearance for procurement.
- 4.14 All the pipes shall conform to the relevant piping standards.
- 4.15 Slings/ wire ropes and other lifting, hoisting or pulling slings used for lifting various loads shall be invariably tested by a test load before carrying out actual erection.

5.0 SPECIFICATION – FIRE PROTECTION SYSTEM**5.1 FIRE PUMPS AND ACCESSORIES**

All Main Pumps shall be capable of delivering 150 % of the rated capacity at 65 % of the rated head and the no-delivery head shall be not more than 120 % of the rated delivery head for split case, multistage and end suction pumps and 140% for vertical turbine pumps. The pump casing shall withstand 1.5 times the no-delivery pressure or 2 times of the duty pressure whichever is higher.

For Jockey pumps Shut off developed by Vertical inline pumps shall not exceed 140% of rated head.

5.1.1 Electric Motor Driven Main Fire Pump (Refer CPWD's general specification for Electrical Works Part-V-2020, Chapter 5 (latest edition will be followed) for details specification)

Electric driven Main Fire Pump suitable for automatic operation and consisting of following, complete in all respects, as required:

1. 2850 lpm at 120 m Head

Supplying, installation, testing and commissioning of Electric driven Main Fire Pump suitable for automatic operation and consisting of following, complete in all respects, as required:

- a. Horizontal type, multistage/single, centrifugal, split casing pump of cast iron body & bronze impeller with stainless steel shaft, mechanical seal conforming to IS 1520 /IS 12469.
- b. Suitable HP Squirrel cage induction motor, TEFC, synchronous speed 1500 RPM, suitable for operation on 415 volts, 3 phase 50 Hz, AC supply with IP 55 protection for enclosure, horizontal foot mounted type with Class-'F' insulation, conforming to IS-325.
- c. M.S. fabricated Common base plate, coupling, coupling guard, foundation bolts etc. as required.
- d. Suitable cement concrete foundation duly plastered with anti-vibration pads.
- e. Post Office Red / Fire Red colour paint shall be as per specification/drawings and as directed by PMC/Employer.

LOCATION: PUMP ROOM**5.1.2 Diesel Engine Driven Main Fire Pump (Refer CPWD's general specification for Electrical Works Part-V-2020, Chapter 6 (latest edition will be followed) for details specification)**

Diesel Engine Driven Main Fire Pump suitable for automatic operation and consisting of followings complete in all respects as required.

1. 2850 lpm at 120 m Head

- a. 1 No. horizontal split casing centrifugal type fire pump capable of delivering 2850 LPM against a total head of 120 metres, so as to ensure a minimum pressure of 3.5 kg. per sq.cm at the farthest topmost hydrant / outlet with pump casing of cast iron to grade FG 200, IS 210-1978 and parts like impeller, shaft sleeve, bearing ring, etc., of non-corrosive metal either like bronze, brass or gun metal and shaft of stainless steel.
- b. Suitable HP, 1500 RPM water cooled with radiator, diesel engine conforming to relevant BS & IS standard complete.
- c. Auto starting mechanism, 12 volts / 24 volts electric starting equipment like self-motor, dynamo, solenoid switches etc.
- d. Diesel engine's day oil tank shall be of capacity sufficient to hold fuel up to 6 hrs of engine operation and mounted over stand fabricated using 25mm x 25mm x 6mm size MS angle providing with level indicator, inlet port, outlet port, drain port and diesel return line port and fuel pre filter, after filter etc. First fill of all consumables including grease, lubricants, oil and diesel fuel. Contractor shall also refill all the consumables after successful testing at the time of handing over the system.
- e. Exhaust system having flexible metallic muffler, 150mm dia MS heavy pipe extended upto 10m outside pump house duly insulated with 50mm thick glass wool with 1mm thick aluminium sheet cladding, residential silencer with necessary MS support arrangements from wall or ceiling as per site condition.
- f. Dashboard consisting of the instruments like Temperature Gauge, Galvano Type DC Ammeter, Lubricant Oil Pressure Gauge, Ignition Switch, Emergency Stop and all other protection equipment's as per specification, stop solenoid for auto stop in the event of fault with audio indications,
- g. 12 V / 24 V, storage battery, maintenance free type, 180AH rating. MS fabricated common base plate, coupling guard, foundation bolts, etc., as required.
- h. Positioning the Diesel Engine Driven Fire Pump over cement concrete foundation using suitable size anti vibration mounting arrangements.
- i. Post Office Red / Fire Red shall be as per specification/drawings and as directed by PMC/Employer.

All works including conveying, fixing and incidental charges, etc., completed as per standard specification and as directed by the PMC/Employer.

LOCATION: PUMP ROOM

The engine shall be cold starting type without the necessity of preliminary heating of the engine cylinders or combustion chamber (for example, by wicks, cartridge, heater, plugs etc.). The engine shall be multi cylinder/vertical 4 stroke cycle, air-cooled, diesel engine, developing suitable HP at the operating speed specified to drive the fire pump. The diesel engine shall be naturally aspirated (non-turbocharged) and electrically started. The engine shall have a speed governor to regulate the rated rpm within 5 % of its rated speed. The engine shall be complete with Auto-start Panel (pressure-switch based), starting batteries full-wave selenium rectifier charger, isolator, leads, mounting frame etc. Engine rating shall be same as for the electric motor inline with the Datasheet.

- Pumps and prime movers shall be truly aligned by using suitable instruments. Record of such alignment shall be recorded in the handing over documents. Contractor shall provide necessary test certificates, performance curves of all the pumps.

- All the pumps shall be provided with approved type of Mechanical seals.
- On the suction and delivery lines, double flanged reinforced neoprene flexible connectors shall be provided. Connectors shall be suitable for maximum working pressure of each pipe line on which it is mounted and tested to a test pressure of 1.5 times the operating pressure.
- Selection of diesel engine — engines, after correction for altitude and ambient temperature, shall have bare engine horse power rating equivalent to the higher of the following two values.
 - a) 20 percent in excess of the maximum brake horse power required to drive the pump at its duty point, or
 - b) The brake horse power required to drive the pump at 150 percent of its rated discharge at 65% of rated head.
- The engine shall be capable of continuous non-stop operation for 8 hours and major overhaul shall not be required before 3000 hours of operation. The engine shall have 10% overload capacity for one hour in any period of 12 hours continuous run. The engine shall accept full load within 15 seconds from the receipt of signal to start. The diesel engine shall conform to BS 649/IS 1601/IS 10002, all amended up to date.
- Diesel pump should have a separate panel, also located in the same pump room or adjoining separate room. The panel should have its separate battery, with battery charging device, and auto-manual changeover arrangement. It should incorporate an interlocking device with the main pump panel so that both the electric pump and the diesel pump do not operate simultaneously. Adequate precaution should be taken to avoid spillage of diesel to avoid any fire exigency.
- **Fuel System** - The fuel shall be gravity fed from the engine fuel tank to the engine driven fuel pump. The engine fuel tank shall be mounted either over or adjacent to the engine itself. The fuel filter shall be suitably located to permit easy servicing.
- All fuel tubing to the engine shall be with MS ERW pipe, with flexible hose connections where required. Plastic tubing shall not be permitted.
- The fuel tank shall be of welded steel construction (3 mm. thick) and of capacity sufficient to allow the engine to run on full load for at least 6 hours. Fuel tank shall be double wall type, so that over flow of the fuel shall be collected in the secondary tank. Fuel supply and return piping shall be with MS ERW pipes with necessary valves. Fuel tank shall be mounted on the fabricated steel supports consisting air vent, over flow, drain, filling level indicator and manhole etc. The outlet shall be so located as to avoid entry of any sediments into the fuel line to the engine.
- As semi rotary hand pump for filling the daily service tank together with hose pipe 5 mtr. long with a foot valve etc. shall also form part of the scope of supply.
- The engine shall be capable of both automatic and manual start. Generally the engine shall start automatically, but in case of the auto-start system failure the engine shall be capable of manual start.

- Provision shall be made for two separate methods of Engine starting viz.
 - a) Automatic starting by means of a battery powered high torque D.C. electric starter motor incorporating the axial displacement type of pinion, having automatic repeat start facilities initiated by a fall in pressure in the water supply pipe to the hydrant installation.
 - b) Manual starting by Electric Starter motor
- The starter motor used for automatic starting may also be used for manual starting provided there are separate batteries for manual starting.
- All controls/mechanisms, which have to be operated in the starting process, shall be within easy reach of the operator.
- **Starting System-** The starting system shall comprise of necessary Auto-start panel (Pressure switch based), maintenance free batteries (2x24v), 24 volts starter motor of adequate capacity and axle type gear to match with the toothed ring on the fly wheel. Bi metallic relay protection to protect starting motor from excessively long cranking runs suitably integrated with engine protection system shall be included within the scope of the work.
- The capacity of the battery shall be suitable for meeting the needs of the starting system.
- The battery capacity shall be adequate for 10 consecutive starts without recharging with cold engine under full compression.
- The means of charging the batteries shall be by 2 rate trickle charger with manual selection of boost charge and the batteries shall be charged in position. Voltmeter to indicate the state of charge of the batteries shall be provided
- **Cooling Water System -** Direct cooling system shall be employed for the diesel engine. Water shall be tapped from the fire pump discharge. This water shall be led through duplex strainer, pressure breakdown orifice and then after passing through the engine, the outlet water shall be taken directly to the sump through an elevated funnel. Re-circulating thermo siphon system of cooling using a fan cooled radiator or indirect cooling system using heat exchanger shall not be accepted.
- **Lubricating Oil System-** Forced feed Lub. Oil system shall be employed for positive lubrication. Necessary Lube.oil filters shall be provided, located suitably for convenient servicing.
- **Governing System-** The engine shall be provided with an adjustable governor to control the engine speed within 5% of its rated speed under all conditions of load up to full load. The governor shall be set to maintain rated pump speed at maximum pump load.
- **Engine Accessories -** The engine shall be complete with the following accessories:-
 - Fly wheel dynamically balanced.
 - Direct coupling for pump and coupling guard.
 - Corrosion Resistor.

- Air cleaner.
 - Fuel service tank support, and fuel oil filter with necessary pipe work.
 - Auto-start panel with Elect. starting battery (2X24 v).
 - Exhaust silencer with necessary pipe work and Insulation.
 - Governor.
 - Instrument panel housing all the gauges, including Tachometer, hour meter and starting switch with key (for manual starting).
 - Necessary safety controls.
- Engine Instrumentation- Engine instrumentation shall include the following:-
 - Lube Oil pressure gauge.
 - Lube Oil temperature gauge.
 - Water pressure gauge.
 - Water temperature gauge.
 - Tachometer.
 - Hour meter.
 - Fuel oil Indication
 - Battery charge indication
- The instrumentation panel shall be suitably resident mounted on the engine.
- Engine Protection Devices- Following engine protections shall be provided:-
 - Low lube oil pressure.
 - High cooling water temp.
 - High lube oil temperature.
 - Over speed shut down.
 - Low fuel oil level
- The scope shall cover all cabling, terminals, initial charging etc.
- Engine Exhaust: The engine exhaust piping shall be amply sized for minimum back pressure and connected to the engine manifold through flexible connection on one side and to a silencer on the other side. The silencer shall be packed type with adequate attenuation for urban use (Residential type), constructed from heavy gauge galvanized steel or as per engine manufacturers standard. The sound absorbent infill shall be no hygroscopic, vermin proof, non-combustible material. The silencer should be adequately sized to impose minimal additional aerodynamic loading on rotor fans and shall have a minimum insertion loss of 15 dBA.
- The exhaust piping from the silencer on wards shall be led up to the top most level and discharged through a rain cowl as shown on drawings. Entire exhaust piping and silencer shall be insulated with 100mm thk 48Kg/cum density fiberglass white wool or rock well The insulation shall be held in position with galvanized steel wire mesh 0.63 dia 20 mesh and finished neatly with 26 SWG Aluminum cladding.
- The exhaust piping shall be fabricated with mild steel as shown in the equipment schedule and all flanged joints shall have spirajet high temperature gasket. The

piping shall be installed with necessary thermal expansion facility as required and shown on drawings.

5.1.3 Jockey Pumps (Refer CPWD's general specification for Electrical Works Part-V-2020, Chapter 5 (latest edition will be followed) for details specification)

Electric driven Jockey Fire Pump suitable for automatic operation and consisting of following, complete in all respects, as required :

1. 180 lpm at 120 m Head

Vertical type, multistage/single, centrifugal split casing pump of cast iron body and bronze impeller with stainless steel shaft, mechanical seal conforming to IS : 1520.

Suitable HP squirrel cage induction motor TEFC type suitable for operation on 415 volts, 3 phase 50 Hz AC supply with IP 55 class of protection for enclosure, horizontal foot mounted type with Class-'F' insulation, conforming to IS : 325.

M.S. fabricated Common base plate, coupling, coupling guard, foundation bolts etc. as required. Suitable cement concrete foundation duly plastered and with anti-vibration pads.

NOTE: Post Office Red / Fire Red colour paint shall be as per specification/drawings and as directed by PMC/Employer.

LOCATION: PUMP ROOM

5.1.4 Electric Motor Driven Terrace Pump (Refer CPWD's general specification for Electrical Works Part-V-2020, Chapter 5 (latest edition will be followed) for details specification)

Supply, erection, testing and commissioning of fire fighting application monoblock motor pumpset of 900 LPM at 40 metres head to develop 3.5 kg/sq.cm at the highest and farthest hydrant point to make 30 m water jet at the time of fire fighting emergency circumstances, coupled with 11 KW / 15 HP rated three phase 414 volts, 50 Hz, 2880 rpm electrical motor the pump with cast iron body, bronze impeller, rope gland packaging, suction size of 80 mm dia. delivery size of 65 mm dia., including the cost of foundation concrete anti vibration mounting, rain safety hood and etc. complete as directed by the PMC/Employer.

M.S.fabricated common base plate, coupling, coupling guard, foundation bolts, with anti vibration pads. etc.as required. Suitable cement concrete foundation duly plastered and with anti vibration pads.

Post Office Red / Fire Red Paint shall be as per specification/drawings complete as directed by the PMC/Employer.

LOCATION: TERRACE FLOOR

5.1.5 Pump Accessories

The Main fire, jockey pumps, Booster pumps shall be complete with the following accessories:

- Suction and discharge eccentric reducers and flexibles.
- Pump coupling & guard.
- Common base frame, fabricated mild steel or cast iron.
- Suction and discharge isolation valves.
- vibration mounts

5.1.6 Soft Starter

(a) Code & Standards

The soft starter must, as a minimum comply with and be certified to:

UL /cUL	UL508
CE	IEC60947-4-2

(b) Environmental Specifications

The soft starter shall be suitable for storage at temperatures from -25 °C to +60 °C.

The soft starter shall be suitable for use at temperatures from -10 °C to 40 °C without derating, and up to 60 °C with derating.

The soft starter shall be suitable for operation at altitudes up to 1000 m above sea level without derating.

The soft starter shall be suitable for use in environments with relative humidity between 5% and 95% (non-condensing).

The soft starter shall use printed circuit boards conformally coated with silicone or similar approved compound.

The soft starter shall be designed to meet Pollution Degree 3

(c) Physical Specifications

The soft starter enclosure shall have IP55 degree of protection.

The soft starter enclosure shall have IP55 degree of protection.

IP20 up to 135 amp units as standard

IP00 above 184 amp units as standard Or

IP20 above 184 amp with optional covers for power terminals.

The soft starter control terminals shall be removable plug type for ease of field wiring.

The soft starter should be capable of being mounted without any additional clearances at the side of the product.

All accessory options such as network communication cards shall be hot-swappable and able to be easily fitted in the field.

All accessory options such as network communication cards shall not increase the overall physical dimensions of the soft starter.

(d) General Electrical Specifications

The soft starter shall be a three-phase controlling type using reverse parallel SCR pairs in each phase of the power section. The SCRs shall have a minimum PIV rating of 1600 V.

The soft starter shall include at least two current transformers for deriving motor current to ensure accurate motor protection.

The nominal ratings information shall be shown on the nameplate label of the soft starter and shall be shown either in the AC53a or AC53b format.

The soft starter shall be correctly selected for the application and rated for a minimum of <x> starts per hour. The soft starter supplier shall provide written confirmation of the soft starter ratings in AC53a or AC53b format.

The soft starter shall be suitable for controlling motors on a wide range of <x> Mains network voltages.

select: 200 VAC to 525 VAC or 380 VAC to 690 VAC

Important when selecting soft starters for global use.

The soft starter control power supply input shall accept a wide range of <x> supply

voltages:

select: 110 to 120 VAC and 220 to 240 VAC +10% -15% or
24 VAC/VDC +10% -15%

Wide control voltage range: Important when selecting soft starters for global use.

24VAC/DC: Important when selecting soft starters for either low voltage battery back-up applications and/or increased general safety due to extra low voltage.

(e) Safety

The control input signals shall be current limited, 24 VDC (supplied by the soft starter internal power supply)

The soft starter shall provide means to safely test its correct installation:

- The soft starter shall provide a means to test the installation using a low power (kW) motor.
- The soft starter shall provide a means to test operation of all control circuitry and protection mechanisms, without connection to mains voltage. Functions to be tested include, at minimum:
 - motor starting
 - motor stopping

(f) User Interface

The soft starter shall be supplied as standard with a built-in graphical user interface specifically designed for operation in conjunction with the soft starter.

The soft starter shall have the option to add a remote graphical user interface. The remote user interface must have a minimum environmental rating of IP65 when panel mounted and must be capable of being mounted flush on the panel door.

The onboard and optional remote display shall display all information in the following user selected languages (English, Spanish, Chinese, French, German, Brazilian Portuguese, Russian, Italian).

The built-in and remote user interface shall comprise as minimum:

- A four line, 16 character, backlit LCD screen for information feedback in <insert language> language and have the ability to display data captured by the soft starter in a graphical format.
- status LEDs indicating
- motor state
- starter control state
- trip status
- local pushbuttons to control:
- menu access
- parameter configuration

The remote user interface shall include the additional functions as minimum:

- local pushbuttons to control:
- motor start
- motor stop
- starter reset
- menu access
- parameter configuration
- parallel operation with built-in user interface
- hot-pluggable operation

The user interface shall provide a means for the operator to quickly access and configure parameters.

The user interface shall display the serial number and software version(s) used within the soft starter.

The user interface shall provide the operator with access to a short list of critical parameters for common applications, including:

- pump (centrifugal or submersible)
- fan (damped or undamped)
- compressor (screw or reciprocating)
- crusher (rotary or jaw)
- conveyor

The soft starter shall permit the operator through the means of standard USB memory stick to:

- save the current configuration to an external file
- reload a previously saved configuration or default set from an external file

- save log contents and diagnostic data to an external file for further analysis
- update firmware
- add additional languages (maximum 11)

The soft starter shall support remote management via a control network with a choice of either:

- ModbusRTU
- Profibus
- DeviceNet
- Modbus TCP
- Profinet
- Ethernet/IP

The control network settings shall be configurable via the soft starter user interface.

The soft starter shall provide an on-board real-time clock. Failure of the real-time clock shall not prevent operation of the starter.

(g) Operating Configurations

The soft starter shall provide the following starting methods:

- Current ramp starting
- Constant current starting
- Adaptive Acceleration Control – to allow the selection of acceleration profiles according to application type and able to self-tune to the motor characteristics.

The soft starter shall provide the following stopping methods

- Timed Voltage Ramp (TVR) soft stop
- Adaptive Acceleration Control – to allow the selection of deceleration profiles according to the application type and able to self-tune to motor characteristics.
- DC braking function. The method of DC braking shall ensure the DC pulses are evenly distributed across all three phases of the power circuit. Methods using only two phase DC braking or that require an external DC braking contactor are not acceptable.
- Soft Brake function. Utilizing built-in changeover relay to control forward run and braking contactors with the ability to automatically stop when motor speed approaches zero through interfacing with the zero speed sensor directly with the soft starter.
- The soft starter shall provide a kick start option for starting the motor. The kick start option will allow a maximum current level and time to be set, uncontrolled voltage boost methods are not acceptable.
- The soft starter shall include a slow speed or jog function that is able to operate both in forward and reverse direction.

- The soft starter shall provide a means of automatically starting and stopping the motor at a predetermined day and time.
- The soft starter shall include shorted SCR functionality, enabling the soft starter to re-start and control the motor even if the soft starter is damaged on one phase (shorted SCR).
- The soft starter shall provide an emergency run feature to allow the soft starter to override any warning or trip conditions thus allowing the motor to run as long as possible in emergency situations.

(h) Motor and System Protection Features

The soft starter shall provide the following protections as standard:

- Motor electronic thermal model
- Excess start time
- Motor over temperature
- Motor thermistor circuit
- Current imbalance
- Frequency out of range
- Phase sequence
- Overcurrent
- Power loss
- Undercurrent
- Input A trip
- Input B trip
- Starter communications
- Network communications
- Bypass contactor failure (where internal bypass is used)
- L1, L2, L3 phase loss
- L1, L2, L3 shorted SCR
- Motor connection
- Heatsink over temperature
- Battery / clock failure
- Remote Keypad Fault

The soft starter's sensitivity to protection situations shall be programmable.

The soft starter's response to a protection activation shall be selectable.

The soft starter's possible responses to a protection activation shall include, at minimum:

- trip: cease operation immediately and disable the motor
- soft trip: cease operation with controlled stop if possible and disable the motor
- warning and log: notify the condition to the operator and continue operating
- log: write the event to memory without tripping

The soft starters fault diagnostics shall be displayed in clear language on the LCD display. The exclusive use of fault codes is not acceptable.

(i) Programmable Outputs

The soft starter shall provide a programmable analog output with the following selectable functionality:

- Current
- Motor temperature
- Heatsink temperature
- Motor power factor

The soft starter shall provide one fixed main contactor output relay and two programmable output relays with user-selectable functionality, enabling indication of, at minimum:

- Low current state
- High current state
- Soft starter operating mode
- Motor temperature state
- Soft Brake Relay
- Run
- Trip states:
- Motor overload
- Current imbalance
- Undercurrent
- Instantaneous overcurrent
- Mains frequency
- Input A trip
- Input B trip
- Heatsink over temperature
- Phase loss
- Motor thermistor

The soft starter shall provide programmable on and off delay times for each of the two programmable relay outputs.

(j) Programmable Control Inputs

The soft starter shall provide at least two programmable inputs with the following functionality:

- Motor parameter set selection
- Auxiliary trip (configurable for either N/O or N/C). The input name shall be customizable by the user.
- Jog Forward
- Jog Reverse

- Zero Speed Sensor
- Emergency Mode
- Command Override (Network, Digital Inputs, Keypad)

The soft starter shall provide for programmable trip delays for each auxiliary input and allow for assignable text to be displayed on the LCD display following an auxiliary trip. The settings for each programmable input shall be fully independent of the other.

(k) Metering and Performance Monitoring

The soft starter shall include comprehensive metering and monitoring functions.

The soft starter shall provide real-time feedback of operating conditions, including:

- starter status
- average current
- L1 current
- L2 current
- L3 current
- mains frequency
- motor temperature (as a % of total thermal capacity)
- motor power factor
- analog output value
- heatsink temperature
- bypass model
- SCR temperature
- rating capacity
- number of starts
- hours run
- current graph
- last start information including starting current and start duration

The soft starter's user interface shall be able to be programmed to display four operating conditions simultaneously on one viewing screen.

The soft starter shall provide feedback of historical operating information, including:

- lifetime hours run
- lifetime start count
- lifetime thermal resets
- resettable hours run
- resettable start count
- resettable thermal resets

The user interface shall allow the user to select which parameters to display on the LCD.

The soft starter shall record full details of its state at the time of every protection activation. The recorded details shall include, at minimum:

- time & date stamp
- protection type
- motor operating status
- mains frequency
- line current
- last start time (if successful)
- motor thermistor
- ambient temperature
- heatsink temperature
- motor thermal model
- SCR temperature
- Bypass model
- Rating capacity

The soft starter shall record all changes to its configuration for storage in an event log. The soft starter's event log shall store no fewer than 384 events.

6.0 PIPES WORK (Refer CPWD's general specification for Electrical Works Part-V-2020, Chapter 7 (latest edition will be followed) for details specification)

6.1 M.S Pipes & Fittings

MS 'C' Class Heavy Duty Pipe as per IS 1239 / 3589 to withstand a developing pressure of 18 kg. / sq.cm including necessary fittings like MS flange of table 'E' as per BS-10 standard, elbows, reducers, gaskets, bolt, nuts with washers & joints as per standard method of arc welding, including shade of finish paint shall be as per IS:5 , one coat metal primer (i.e. dry film thickness (DFT) 25 microns per coat) and two coat Post Office Red / Fire Red paint (i.e. minimum dry film thickness (DFT) 25 microns per coat. Total DFT 50 microns minimum.) as directed by PMC/Employer painting including conveyance, all incidental charges, necessary scaffolding and re-doing the dismantled portions to its original condition wherever found necessary, etc., complete as per standard specification and as directed by the PMC/Employer,

- MS Fittings(40 mm dia. and below shall be Forged Steel fittings as per ASTM A 105 3000CL, end connection Socket welded as per ASME B16.11. & One side socket weld and other side threaded as per NPT for fittings used for sprinklers
- M.S Fittings of 50 mm dia & above shall be as per ASTM A 234 Gr. WPB all fittings shall be BW seamless fittings type as per specifications.
- All Fire pipe headers/riser shall be worded indicating the direction of the flow and its purpose such as "TO RISER NO.1" as per PMC/Employer /CFO requirement etc.
- Pipe Support for pipe size 65mm & below shall be G.I Universal clamps with threaded rod. For pipe size 80mm & above, the support shall be Clevis Hanger with threaded rod. Where a group of pipes run together, they shall be supported with Galvanised Iron structure support.
- Contractor shall perform appropriate calculations and design the structural pipe supports. Universal clamps and Clevis hangers shall be selected for the appropriate load.

6.2 G.I Pipes & Fittings

GI 'B' Class Medium Duty to withstand a developing pressure of 10 kg. / sq.cm & 'C' Class Heavy Duty Pipe as per IS 1239 to withstand a developing pressure of 18 kg. / sq.cm including necessary fittings like MS flange of table 'E' as per BS-10 standard, elbows, reducers, gaskets, bolt, nuts with washers & joints as per standard method of arc welding, including shade of finish paint shall be as per IS:5, one coat metal primer (i.e dry film thickness (DFT) 25 microns per coat) and two coat Post Office Red / Fire Red paint (i.e. minimum dry film thickness (DFT) 25 microns per coat. Total DFT 50 microns minimum.) as directed by PMC/Employer painting including conveyance, all incidental charges, necessary scaffolding and re-doing the dismantled portions to its original condition wherever found necessary, etc., complete as per standard specification and as directed by the PMC/Employer,

- G.I Fittings (40 mm dia. and below shall be Forged Steel fittings as per ASTM A 105 3000CL, end connection Socket welded as per ASME B16.11. & one side socket weld and other side threaded as per NPT for fittings used for sprinklers.
- G.I Fittings of 50 mm dia & above shall be as per ASTM A 234 Gr. WPB all fittings shall be BW seamless fittings type as per specifications.
- All Fire pipe headers/riser shall be worded indicating the direction of the flow and its purpose such as "TO RISER NO.1" as per PMC/Employer /CFO requirement etc.
- Pipe Support for pipe size 65mm & below shall be G.I Universal clamps with threaded rod. For pipe size 80mm & above, the support shall be Clevis Hanger with threaded rod. Where a group of pipes run together, they shall be supported with Galvanised Iron structure support.
- Contractor shall perform appropriate calculations and design the structural pipe supports. Universal clamps and Clevis hangers shall be selected for the appropriate load.

6.3 Underground Centrifugally cast (spun) Ductile Iron Piping

a. Ductile Iron (Di) Pipes and Fittings

- Ductile iron pressure pipes and fittings shall be Class K9 (Pipe) / K12 (fittings) unless otherwise shown on the drawings and shall comply with IS: 8329 and IS: 9523. All fittings shall be socketed unless specified otherwise. Ductile iron pipes and fittings spigot and socket type shall be used for external fire piping work.
- Material - The materials used in the manufacture of pipes and fittings shall comply with IS: 8329 and IS: 9523. All fittings shall be socketed unless otherwise specified.
- The materials used in the manufacture of pipes and fittings shall comply with IS: 8329 and IS: 9523. All fittings shall be socketed unless otherwise specified.

b. Installation

- DI pipes (Class K9) and DI fittings (Class K12) with internal Cement Mortar lining shall be in accordance with IS: 8329 and IS: 9523. Pipes shall be ISI marked.
- Pipes and fittings shall be procured from reputed manufacturers with Engineer's approval. Engineer shall at all reasonable times have free access to the place where the pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.
- The pipes will be centrifugally cast (spun) Ductile Iron pipes for Water and Sewage as per relevant ISO (amended up to date) having specifications/properties equal to or superior to the IS: 8329 - 2000 (amended up to date). The pipes used will be with push on joints (Rubber Gasket Joints).
- The flange connection shall be used only in cases of fittings or specials or under special circumstances as directed by Engineer. The pipes shall be externally coated with bitumen as per Appendix C of the IS: 8329 - 2000 and have factory provided cement mortar lining in the inside as per the provisions of Appendix B of the IS: 8329 - 2000.
- The pipes shall be supplied in standard length of 5.50- and 6.00-meters length with suitably rounded or chamfered ends. Each pipe of the push on joint variety shall also be supplied with a rubber ring (EPDM/ SBR) gasket. Any change in the stipulated lengths will be approved by the Engineer. The gaskets will confirm to the IS: 5382 - 1985 and IS: 12820.
- The manufacturer of the pipes should also supply the specials and gaskets. The manufacturer of the pipes should preferably manufacture them. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under its own supervision and have it tested at his/ sub contractor's premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.
- The flanged joints will confirm to the clause 6.2 of IS: 8329. The pipe supply will also include one rubber gasket for each flange.
- All tests specified either in this specification or in the relevant Indian Standards specified above shall be performed by the Supplier/ Contractor at his own cost and in presence of Engineer, if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to Engineer.
- If the test is found unsatisfactory, Engineer may reject any or all pipes and fittings of that lot. The decision of Engineer in this matter shall be final and binding on the Contractor and not subject to any arbitration or appeal.
- The pipes and fittings shall be stripped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects. Any defect in pipes and fittings in the opinion of Engineer shall be rejected and shall be replaced by new one.
- In the case of spigot and socket pipes and fittings the socket shall be without the centering ring.

- In the case of flanged pipes, the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the center line. The bolt hole circle shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.
- All the DI fittings shall be supplied with one rubber ring for each socket.

c. Dimensions and Tolerances

- The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS: 8329/ IS: 9523 for different class of pipes and fittings. Standard length of 6 m of pipe is recommended and other properties for pipes and fittings shall be as per IS: 8329/ IS: 9523. Each pipe supplied shall be of uniform thickness throughout its length. The tolerances for pipes and fittings regarding dimensions, mass, ovality and deviations from straight line in case of pipes shall be as per IS: 8329/ IS: 9523.

d. Lubrication for DI Pipe Work

General

- This section covers the requirements for lubricant for the assembly of Ductile Iron pipes and specials suitable for Tyton push-on rubber ring joints.

Specification

- The lubricant must have the following characteristics: must have a paste like consistency and be ready for use.
- must adhere to wet and dry surfaces of DI pipes and rubber rings.
- to be applied in hot and cold weather; ambient temperature 0 - 50°C, temperature of exposed pipes up to 70°C.
- must be nontoxic.
- must be water soluble.
- must not affect the properties of the drinking water carried in the pipes.
- must not have an objectionable odor.
- must not be harmful to the skin.
- must have a shelf live not less than 2 years.

Acceptance Test

They shall be conducted in line with the provisions of the IS: 9523.

e. Jointing

- Jointing of DI pipes and fittings shall be done as per IS: 12288 and manufacturer's recommendations. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. Rubber sealing rings/ V gaskets used for jointing shall conform to IS: 638, IS: 12820 and IS: 5382.

i. Spigot and Socket Joints

- These shall have sockets which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS: 12820 and rubber rings shall be as per IS: 5382.
- In jointing DI pipes and fittings, the Contractor shall take into account the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, so that the rubber ring as per IS: 12820 and IS: 5382 is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier or as otherwise directed by the Engineer.

ii. Gaskets for Flanges

- The gaskets used between flanges of pipes shall be of EPDM conforming to IS: 638 of thickness between 1.5 to 3 mm suitable for sewage conveyance.

iii. Flanged Joints

- These shall comply with dimensions and drilling details in IS: 8329 for PN 20 flanges. All flanged joints between steel and ductile iron pipe work shall be electrically isolated joints. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All materials shall be supplied by a specialist manufacturer and be to the approval of the Engineer.
- Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The recommended bolting torque to be followed for assembling flanges shall be as specified in manufacturer's instructions. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified. They shall be coated with coal tar epoxy coating after tightening.

iv. Cement Mortar Lining

- All pipes and fittings shall be internally lined with cement mortar in accordance with ISO: 4179/ IS: 11906. Cement mortar lining shall be applied at the factory in conformance with the above-mentioned standards. No admixtures in the mortar shall be used without the approval of the Engineer.
- Pipe linings shall be inspected on site and any damage or defective areas shall be made good to the satisfaction of the Engineer. The Contractor may use specialist mortars, mortar additives or curing agents only with the approval of the Engineer.
- Lining shall be uniform in thickness all along the pipe. The minimum thickness of factory applied cement mortar lining shall be 3 mm for DN 300 mm pipe; 5 mm for DN 350 to 600 mm pipe; and 6mm for DN 800 mm pipes.

Certain sections are amplified as follows:

- No additives shall be used without the written approval of the Engineer and shall be used strictly in accordance with the manufacturer's recommendations.
- The minimum thickness of the lining at one point shall not be less than 4 mm.

v. Specials

- Standard DI fittings (Class K9) shall be in accordance with IS: 9523. Wherever standard DI specials are not available, they shall be manufactured and tested as per requirements with the approval of Engineer.

f. Coatings**General**

Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Buried pipes and fittings shall also have a site or factory applied polythene sleeving. Coating shall not be applied to pipe and fittings unless its surface is clean, dry and free from rust. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer.

Zinc Coating

Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m² as described in Clause 5.2 of ISO 8179.

Bitumen Coating

Bitumen coating shall be of normal thickness 75 microns unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS: 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions. Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

Pipe flow direction

All pipes shall have flow direction and system types. This will be done by standard stencils, prepared with letter sizes as conveyed. Minimum letter height is 1-1/4 inches for ducts and 3/4 inch for pipes. Stencil Paint: Exterior, oil-based alkyd gloss black enamel, except as otherwise indicated. Paint may be in pressurized spray-can form.

Testing

Tests on pipes and fittings shall be carried out in accordance with IS: 8329 and IS: 9523. The Engineer shall be permitted free access to the place of manufacture for the purpose of examining and witnessing the testing of pipes and fittings.

Failure to Pass the Test

All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to be unsatisfactory in any way shall be redone by the Contractor.

7.0 VALVES Refer CPWD's general specification for Electrical Works Part-V-2020, Chapter 7 (latest edition will be followed) for details specification)

7.1 Sluice Valve

Sluice Valve specification of double flanged Sluice valve of rating PN 16 & PN20 with non-rising spindle, bronze/gun metal seat, ISI marked complete with nuts, bolts, washers, gaskets and conforming to IS 14846 / IS 780 of following sizes as required :

NOTE:

Post Office Red / Fire Red paint shall be as per specification/drawings and as directed by PMC/Employer

7.2 Butterfly valve

Butterfly Valve specification of Butterfly valve of PN 16 rating with C.I body, Cast Bronze or Stainless Steel disc, stainless steel shaft, Either integral or Nitrile rubber seat , Nitrite/ Silicon O-ring duly ISI marked complete with nuts, bolts, washers, gaskets conforming to IS 13095 of following sizes as required :

NOTE:

Post Office Red / Fire Red shall be as per specification/drawings and as directed by PMC/Employer

7.3 Ball valve

Male/ female screwed end full way lever operated forged brass Ball valve of PN 16 & PN 20 rating brass body with forged brass hard chrome plated ball & teflon seat, with (threaded joints) complete as required. including necessary teflon tape etc complete as per specification as specified inclusive of all accessories required for satisfactory installation as per specification/drawings and as directed by PMC/Employer.

NOTE:

Post Office Red / Fire Red paint shall be as per specification/drawings and as directed by PMC/Employer

7.4 Non-Return Valve

Non-return valve of PN 16 & 20 rating of following sizes confirming to IS: 5312 complete with rubber gasket, GI bolts, nuts, washers etc.as required :

NOTE:

Post Office Red / Fire Red paint shall be as per specification/drawings and as directed by PMC/Employer

7.5 Air Release Valve

Air Release Valve of 20mm dia, so as to release airlock in 150mm dia MS pipe at topmost wet riser, including conveyance, all incidental charges, necessary scaffolding and re-doing the dismantled portions to its original condition wherever found necessary, etc., complete as per standard specification and as directed by the PMC/Employer

7.6 Y Strainer

Stainless Steel body Y- strainer screen fabricated out of 1.6 mm thick stainless steel, Grade 304, sheet with 3 mm dia holes with Stainless Steel flange.

NOTE:

Post Office Red / Fire Red paint shall be as per specification/drawings and as directed by PMC/Employer

7.7 Air Vessel

Air vessel made of 250 mm dia, 8mm thick MS sheet, 1200 mm in height with air release valve on top and flanged connection to riser, drain arrangement with 25 mm dia gun metal wheel valve with required accessories, pressure gauge and painting with synthetic enamel paint of approved shade as required.

NOTE:

Post Office Red / Fire Red shall be as per specification/drawings and as directed by PMC/Employer

7.8 Pressure relief valve – UL Listed/FM Approved

UL Listed/FM Approved pilot operated Pressure relief valve - 150 mm of Ductile Iron body, Brass trim, Buna-N Synthetic Rubber with Direct Acting - Precise Pressure Control, Drip Tight Closure, drain arrangement. It shall have adjustable setting in range suitable for operating range of the pump. The relief valve outlet shall be led back to the tank. All accessories' nuts, bolts, washer, connector and pipe fittings etc. as per specification/drawings and as directed by PMC/Employer.

NOTE:

Post Office Red / Fire Red paint shall be as per specification/drawings and as directed by PMC/Employer

7.8 Pressure reducing valve – UL Listed/FM Approved

UL listed Pressure reducing valve set for Sprinkler system comprising of 1 No pilot valve, 2 Nos C.I Butter Fly valves on inlet & outlet, 1 No. UL listed pressure reducing valve with flanged connection, 2 Nos Pressure gauge on inlet & outlet. The complete system is tested to a pressure not less than 18 Kg/Sq.cm and suitable to reduce the pressure upto 3.5 Kg/Sq.cm) Including flanges/ unions, nuts, bolts and washers complete as required as per specification/drawings and as directed by PMC/Employer.

NOTE: The PRV shall be installed in an accessible location.

Inlet Pressure: Max. 12 Kg/Sq.cm

Outlet Pressure: 9.5 Kg/Sq.cm

7.9 EPDM rubber Expansion joint

Heavy duty floating flange EPDM rubber expansion joint with unit control (tie rod & gusset plate) as per manufacturers specifications of standard length complete with all accessories tested to a pressure not less than 15 Kg./sqcm including rubber gaskets, flanges, nuts, bolts & washers complete as required as per specification/drawings and as directed by PMC/Employer.

7.10 Globe Valve

Bronze Globe valve, PN16 & 20 conforming to IS 778 screwed in bonnet, Bronze body, disc & stem union flanges, washer nuts & bolts, rising stem, connectors, adapters etc.

complete, high quality PTFE gland packing with necessary unions, complete as per specification/drawings and as directed by PMC/Employer.

8.0 INSTRUMENTATION

8.1 Pressure Switches

Pressure switch in M.S. pipeline including connection etc. as required.

Notes: Adjustable type pressures switch suitable for operating with hydrant & sprinkler systems for working pressure of 18Kg/cm² pressure including electrical wiring complete as required. Vendor also need to submit the calibration certificate of Pressure switch.

8.2 Pressure Gauge

Pressure gauge(suitable for working pressure of (0-20 Kg/cm²(g)) of Stainless Steel with 6 inch phenolic dial (white dial with black numerals), 316 SS Bourdon tube, nylon movements and micrometer type adjustable aluminium pointer with accuracy of +/- 0.1% of span including accessories like siphons for steam services, snubbers for pump discharge applications and chemical diaphragm for corrosive and oil services and name plate, etc. Material of accessories shall be SS. IP65 degree of protection for enclosure. Over range protection shall be 50% above maximum pressure. Armoured capillary of 15 M shall be provided as per specification.

8.3 Venturi Type Flow Test Meter (FM Approved)

FM approved Venturi Type Flow Test Meter with waste cone on Test Line to measure 150% of pump flow and suitable for mounting on 150 mm dia pipe as per specifications.

9.0 HYDRANT ACCESSORIES Refer CPWD's general specification for Electrical Works Part-V-2020, Chapter 8 (latest edition will be followed) for details specification)

9.1 Internal hydrant valve:

Oblique type Single Headed Stainless Steel Hydrant Valve of size 63mm dia with oblique type instantaneous coupling with rotating wheel to open and close the valve including MS flange of table "E" as per BS-10 standard,, bolts & nuts with washer as per IS 5290 at ring main around the building and wet riser inside the building including conveyance, all incidental charges, necessary scaffolding and re-doing the dismantled portions to its original condition wherever found necessary etc complete as per standard specification and as directed by the PMC/Employer

9.2 External Hydrant Valve:

Single headed Stainless Steel External Yard Hydrant Valve with 1 No. 63 mm dia instantaneous FM Stainless Steel coupling and cast-iron wheel, ISI marked, conforming to IS 5290 (type A) with blank Stainless-Steel cap and chain as required.

9.3 Short branch pipe:

63mm dia Stainless Steel Short length branch pipe with hexagonal type spray nozzle of 20mm jet bore. Near every hydrant point including conveyance, all incidental charges, necessary scaffolding and re-doing the dismantled portions to its original condition wherever found necessary, etc., complete as per standard specification and as directed by the PMC/Employer.

9.4 RRL hose pipe:

RRL Type-A Hose of 63mm dia of 15 metres length binded by copper wire with 63mm dia stainless steel male and female instantaneous firefighting special coupling as per IS 901 as directed by the PMC/Employer Near every hydrant point including conveyance, all incidental charges, necessary scaffolding and re-doing the dismantled portions to its original condition wherever found necessary etc complete as per standard specification and as directed by the PMC/Employer.

9.5 First-aid Hose Reel:

First Aid Hose Reel Drum assembly by disconnecting from hydrant line, replacing shut off nozzle, warm clip, lubricating the rotating assembly, replacing 20mm dia, 30 metres long rubber hose, reconnecting with hydrant system as per standard methods and as directed by the PMC/Employer.

9.6 Fire Hose Cabinet:

MS Hose Box to keep two number of hoses and 1 No. of branch pipe with nozzle having proper glass window type double door with universe open key, painted inside white and outside Post Office Red. Near every hydrant point including conveyance, all incidental charges, necessary scaffolding and re-doing the dismantled portions to its original condition wherever found necessary, etc., complete as per standard specification and as directed by the PMC/Employer

- Floor mounted / Wall mounted hose cabinets shall be provided with minimum 1 m high structural support legs of ISMC 100 as per the standard drawing.
- Canopy (sloping top) is required for hose cabinets to be located outdoors.
- The word “fire”, in 150 mm letter size in red, shall be painted on the cabinet glass.
- The cabinet shall be provided with clamps for holding branch pipe, nozzle and hose reel where applicable.
- Provision to keep one key and one hammer in glass covered recess on the side of the cabinet shall be made.
- The colour shall be uv resistant fade proof integral type suitable for external atmosphere.

9.7 Indoor Type Fire Hose Cabinet:

Lockable Indoor type Fire Hose Cabinet, frames fabricated from 40 x 40 x 5 angle iron sections and 16-gauge MS sheet with glass door (with M.S. frame) and locking arrangement, suitable to accommodate landing valves, 2 nos. 15 m long hoses, first-aid hose reel and branch pipe nozzle & fire mans' axe. The cabinet frame shall be painted with one coat of primer and two or more coats of synthetic enamel paint of approved make and shade of as required (Approx. 1.5 m (high) x 0.9 m (wide) x 0.6 m (deep)). The item shall be complete of MS housing with front door Colour/shade of Paint shall be as per specification/drawings and as directed by PMC/Employer.

9.8 Fireman Axe

Fireman Axe with heavy duty insulated rubber handle as per IS: 926 with clamps.

9.9 Fire brigade connection:

Fire brigade connection of cast iron body with gun metal male instantaneous inlet couplings complete with cap and chain as reqd. for suitable dia GI pipe connection conforming to IS 904 as required for 2 way-100 mm dia G.I. Pipe and 4 way - 150 mm dia G.I. Pipe

9.10 Valve Box for Fire brigade connection:

SS cabinet (to enclose Fire Brigade and draw-out connection as per Item above) fabricated from 16 g SS 304 sheet with full front glass door and locking arrangement duly painted with one coat of primer and two or more coats of synthetic enamel paint of approved make and shade and suitably mounted on a raised masonry platform as required (Approx. 0.6 m x 0.6 m x 0.45 m)

9.11 Foot valve with strainer

Heavy Duty Foot Valve including all accessories, such as, MS flange of table 'E', gaskets, bolts & nuts, etc., installed at end of 150 / 200mm dia suction pipe line at sump including conveyance, all incidental charges, necessary scaffolding and re-doing the dismantled portions to its original condition wherever found necessary, etc.

CI flanged end Foot valve as per IS 4038/1979 with strainer with necessary rubber insertion/bolts and nuts etc complete as per specification/drawings and as directed by PMC/Employer.

9.12 Orifice plate

Orifice plate made out of 6 mm thick stainless steel (Grade 304) with orifice of required size to be fitted between flange & landing valve of external and internal hydrants to reduce pressure at the outlet to the level of 3.5 kg/cm² complete as required

NOTE: The bore of the orifice shall be designed by the Contractor in order to get hydrants valve outlet pressure of 3.5 kg/cm².

For restricting pressure in the system, orifice plates of appropriate sizes shall be fitted at all floor levels, at the branching points from Riser Main as shown in drawings and as required.

The Diameter of such orifice shall not be less than 50% of the dia of pipe into which it is to be fitted,

These orifice plates' plain central hole must be without burrs. Such orifice plate must have a projecting identification tag.

The orifice plate shall be fitted at a distance of not less than two pipe internal diameters downstream of the outlet from any elbow or brand.

Contractor shall submit the design for PMC/Employer approval and identify location on drawing before installation.

9.13 "J" type hooks

"J" type hook supports made of 25 mm dia pipe to support 2 nos. 15 m long hoses and 01 No short branch pipe. It should be inclusive of required anchor fastener, nuts, etc.

10.0 AUTOMATIC SPRINKLER SYSTEM Refer CPWD's general specification for Electrical Works Part-V-2020, Chapter 9 (latest edition will be followed) for details specification)

10.1 Installation Control Valve

Installation control valve of Cast Iron body, 17.5 kg/sq.m brass/bronze working parts comprising of water motor alarm, SS-304 clapper, clapper arm and hydraulically driven mechanical gong bell to sound continuous alarm when the wet riser/sprinkler system activates, pressure gauges, emergency releases, strainer, pressure required valve complete with drain valve and bypass, test control box, ball valves, MS pipe of required size, flanges, orifice plate, gasket etc of following sizes as required :

NOTE:

Post Office Red / Fire Red color paint shall be as per specification/drawings and as directed by PMC/Employer

10.2 Zone Control Valve - UL Listed/FM Approved

UL Listed Zone/Floor Control Valve flanged end with fitting, suitable for working pressure of 18kg/sq.m including 50 mm Inspectors test drain valve assembly complete with test bronze valve, bronze sight glass, sectional drain valve, union with pressure gauge, electrically operated flow indicating switch (vane type) of following diameter with threaded connection with flexible full bore paddle & NO/NC contact terminals with all accessories and necessary wiring all complete strictly as per specification/Drawing as per specification/drawings and as directed by PMC/Employer. The system shall consists of following:

- Butterfly valve (along with supervisory switch as applicable & to be interfaced with fire alarm) Tamper Switch for Butterfly valves with BMS compatible of the following diameters complete with all necessary accessories, the tamper switch shall be provided with potential free contact with 2 nos. NO/NC as per drawings and as directed by PMC/Employer.
- Orifice plate
- Flow switch (To be interfaced with fire alarm system)
- Pressure gauge with isolation valve.
- Test and Drain valve Assembly (UL Listed/FM Approved)* all above components shall be as per standard details.

Flow Switch specification is below.

- Flow switch shall have a paddle made of flexible and sturdy material of the width to fit within the pipe bore.
- The terminal box shall be mounted over the paddle/ pipe through a connecting socket.
- The Switch shall be potential free in either NO or NC position as required.
- The switch shall be able to trip and make / break contact on the operation of a single sprinkler head.
- The terminal box shall have connections for wiring to the Annunciation Panel.

- The flow switch shall have connections for wiring the seat shall be of S.S to the Annunciation Panel.
- The flow switch shall have IP: 55 protections.
- The flow switches work at a triggering threshold bandwidth (flow rate) of 4 to 10 GPM. Further, it shall have a 'Retard' to compensate for line leakage or intermitted flows.

10.3 Pendant type sprinkler (93 degree) - UL Listed/FM Approved

UL Listed/FM Approved 15 NB, 93 deg., K-Factor 5.6 (80), Pendant type, Standard Response, Quartzoid bulb sprinkler with adjustable rosette plate, teflon tape, lock tite solution with required accessories etc. complete as per specification/drawings and as directed by PMC/Employer.

10.4 Pendant type sprinkler (68 degree) - UL Listed/FM Approved

UL Listed/FM Approved 15 NB, with 68°C. temperature rating for Sprinkler bulb and 57°C. for Cover Plate, K-Factor 5.6 (80), Pendant type, Standard Response, Quartzoid bulb sprinkler adjustable royal flush Concealed sprinkler, teflon tape, lock tite solution with required accessories etc. complete as per specification/drawings and as directed by PMC/Employer.

10.5 Concealed royal flush sprinkler (68 degree) - UL Listed/FM Approved

UL Listed/FM Approved 15 NB, with 68°C. temperature rating for Sprinkler bulb and 57°C. for Cover Plate, K-Factor 8 (115), Pendant type, Standard Response, Quartzoid bulb sprinkler adjustable royal flush Concealed sprinkler, teflon tape, lock tite solution with required accessories etc. complete as per specification/drawings and as directed by PMC/Employer.

10.6 Upright sprinkler (68 degree C) - UL Listed/FM Approved

UL Listed/FM Approved 15 NB, 68 deg., K-Factor 5.6 (80), Upright type, Standard Response, Quartzoid bulb type sprinkler Coverage Area 9 sq.mtr, teflon tape, lock tite solution with required accessories etc. complete as per specification/drawings and as directed by PMC/Employer.

10.7 Side wall type (68 degree) - UL Listed/FM Approved

UL Listed/FM Approved 15 NB, 68 deg. , K-Factor 5.6 (80), Side wall type, Standard Response, Quartzoid bulb, recessed type sprinkler with adjustable rosette plate,, Standard Coverage, teflon tape, lock tite solution with required accessories etc. complete as per specification/drawings and as directed by PMC/Employer

10.8 Pendent type (68 degree) - UL Listed/FM Approved

UL Listed/FM Approved 15 NB, 68 deg. K 5.6 (80), Pendant type, Standard Response, Quartzoid bulb sprinkler, teflon tape, lock tite solution with required accessories etc. complete as per specification/drawings and as directed by PMC/Employer.

10.9 Sprinkler flexible pipe (UL Listed)

Sprinkler flexible pipe (UL Listed) of stainless steel complete with 15 NPT on reducer thread with maximum working pressure of 175 PSI test pressure of 875 PSI (Burst) with branch line (Inlet) 25mm NPT male thread to sprinkler head (Outlet) 15mm NPT female

thread with reducer, nipple, 2 side brackets, center bracket, stockbar of following sizes complete as required.

10.10 Spare Sprinklers

Spare sprinkler MS cabinet fabricated from 16-gauge MS sheet (duly painted over a coat of primer) with full front glass door & locking arrangement with suitable sheaves for keeping spare sprinkler of each type (as desired above) & two nos spanner properly fixed in shelves. Cost shall be for individual cabinet comprising of spare sprinkler stored as indicated below:

10.11 Sprinkler annunciation panel

Sprinkler annunciation panel 230 V AC input, 50 Hz AC supply & 24 VDC output, standby 24 V DC, operating temperature 00C to 400C which shall be of microprocessor based with LED indicators, comprising of 64 Zones with Modular PCB board type visual and audible fire and fault alarms and signals, indicators, call individual or call all, Evacuation alarm facility with pulse timer, Power supply unit etc., complete with stove enameled housing, glass door with locking facility as per detailed specification. located in the lobby area as per the drawing. The Annunciation Panel shall be complete with 2 x 12 VDC sealed maintenance free batteries with battery charger & housed in CRCA sheet steel cabinet (3 mm thick), dust & vermin proof (IP 65) with provision for audio-visual indication. The Annunciation Panel shall be provided with Potential free contacts to enable BMS compatibility kept to main power panel interlink of Ethernet port, along with patch card readable to BMS as per specification/drawings and as directed by PMC/Employer. Armoured FRLS control wires 2C x 1.5 sqmm made of PVC insulated copper conductor, PVC sheathed, confirming to IS 1554 etc., complete as per Instrumentation specification.

10.12 FRLS Control wires

Armoured FRLS control wires 2C x 1.5 & 2C x 2.5 sq.mm made of PVC insulated copper conductor, PVC sheathed, confirming to IS 1554 etc. shall include all fittings, jointing, glands, lugs, bracing, clamping, fastening, chasing, termination and testing. complete as per specification/drawings and as directed.

11.0 CLEAN AGENT GAS BASED FIRE SUPPRESSION SYSTEM

11.1 Clean Agent system

a. General

The Contractor shall supply, install, test, commission and put in operation CLEAN AGENT SYSTEM based fire suppression system. The fire suppression system shall include and not be limited to gas release control panel, CCOE/PESO Approved UL/ FM/ VDS Listed agent FK-5-1-12 or equivalent Cylinder and Valve Assembly, 120 Ltrs Ltr seamless cylinder capacity, Liquid at site (fill density not more than 0.89Kg/ litre), pressurised to 25 / 42 bar along with Hydraulic UL/ VD Flow Calculations for the Suppression areas, and vetting of the Software from the OEM Factory Engineer as per specification/drawings and as per specification/drawings and as directed by PMC/Employer .

Below compliance are mandatory to comply with PESO, Gas cylinder rule and compressed gas cylinder rule.

a) PESO License for Valve &

This operating system shall meet NFPA 2001 : 2022 standards and installed in compliance with all applicable requirements of the local codes and standards.

The system design should be based on the specifications contained herein, NFPA 2001: 2022 and in accordance with the requirements specified in the design manual of the OEM. The Contractor, shall confirm compliance to the above along with their bid.

The system shall be properly filled and supplied by a UL / Vds/ FM Approved OEM (Original Equipment Manufacturer)

The Clean Agent Gas Based Fire Suppression System shall:

- Comply with NFPA 2001:2022
- have the approval from US EPA (Environmental Protection Agency) for use as a total flooding fire extinguishing for the protection of occupied space:
- be given Underwriters' Laboratories Inc. (UL / Vds / FM approved) component listing for the CLEAN AGENT SYSTEM gaseous agent.
- Maximum operating pressure should not be more than 70 bar
- must have zero ozone depletion potential (ODP)
- have a minimal life span in atmosphere, with atmospheric lifetime of less than 5 days
- be efficient, effective and does not require excessive space and high pressure for storage.
- commercially available
- Seamless cylinders
- Complete design & flow calc should be verified and approved by Original Equipment Manufacturer (OEM)
- Complete system should be approved by Original Equipment Manufacturers mentioned in Approved Makes List
- Distributors have to provide the project specific authorization letter from OEM
- Global Warming Potential of Gas should not be more than 1.
- OEM's UL /Vds/FM certificates shall be submitted along with bid
- PESO approval for pressurized cylinders shall be furnished for seamless cylinders and valves separately.
- 100% online Stand-by cylinders of clean agent shall be provided for restoring the area protection after discharge of main bank of cylinders.

b. Design Condition

- The Clean Agent System agent shall be stored in seamless steel cylinders and super pressurized with dry nitrogen to provide additional energy to give the required rapid discharge. At the normal operating pressure of 25 to 70 bars at 21o C, the agent is a liquid in the cylinder.

- The designer shall consider simultaneous flooding of all voids within the protected volume. The system shall be designed in accordance with the OEM's Design Manual.
- To extinguish a fire using clean agent, the concentration of agent delivered to each void shall be above the minimum design concentration. The following shall be considered while designing the system.
- Minimum design concentration shall be 4.5% at 21 deg centigrade for class C fire
- If the protected volume has a floor and / or ceiling void the spaces shall be included in the protected volume, employing a minimum design concentration not below that of the main room compartment.
- The discharge nozzles shall be located within the protected volume in compliance to limitations and regarding spacing, floor and ceiling coverage, etc. The nozzles shall be positioned such that they would cover the entire area up to the extreme corners of the area under protection and the design concentration will be established in all parts of the protected volumes. Vendor needs to submit Acoustic calculation reports for all rooms with electronic data storage to determine the sound decibel level in accordance with difference sound frequency with nozzle to storage distance as 1mtr.
- The average pressure at each should be as per OEM recommendation.
- The gas flow calculation shall be carried out on special software given by the OEM. The software should support usage of seamless cylinders which have a different design compared to the standard containers used worldwide. The system acceptance report shall show the resulting concentration in each independent void to be above 4.5%.
- The agent discharge time shall not exceed 10 seconds and not less than 5 seconds.
- The design concentration shall follow at minimum NFPA 2001 for under floor, room and ceiling space. Unless otherwise approved, room temperature for air-conditioned space shall be taken around 21°C. For non-air-conditioned space, the temperature shall be taken around ambient temperature. The system shall be designed with minimum design concentration of 4.5 % as applicable to Class A fire & 4.5% for Class C Fire.
- The system engineering company should carry out the piping Isometric design and validate the same with a hydraulic flow calculation generated by using the agent's design software. Appropriate fill density to be arrived at based on the same.
- The system shall be so designed that a fire condition in any one protected area shall actuate automatically the total flooding of clean agent in that area independently. The entire system shall incorporate inter-alia detection, audible and visual alarms, actuation and extinguishing.

11.2 Cylinders

- CCOE/PESO Approved UL/ FM/ VDS Listed agent FK-5-1-12 or equivalent Cylinder and Valve Assembly, 120 Ltrs Ltr seamless cylinder capacity, Liquid at site (fill density not more than 0.89Kg/ litre), pressurised to 25 / 42 bar along with Hydraulic UL/ VD Flow Calculations for the Suppression areas, and vetting of the Software from the OEM Factory Engineer as per specification/drawings and as per specification/drawings and as directed by PMC/Employer .
- Below compliance are mandatory to comply with PESO, Gas cylinder rule and compressed gas cylinder rule.
 - a) PESO License for Valve &
 - b) PESO License for Cylinder
- UL/ VDS/FM Listed Nitrogen Pilot Cylinder for actuation of main cylinder in case the main cylinders are kept within the risk room / multiple bank to be operated with one actuation. The Pilot cylinder shall be PESO approved and the pilot cylinder valve also needs to be PESO approved.
- Each cylinder shall be seamless steel type manufactured from billets and tested in accordance with IS 7285 / BS 5045 standard and approved by PESO.
- The cylinder/valve assembly shall have suitable metallic protection for the valve enabling transportation of the filled cylinders safely.
- The cylinders shall be super-pressurized with dry Nitrogen to 25 bar – 70 bar. The cylinder shall be capable of withstanding any temperature between -30 Deg C and 70 Deg C.
- All cylinders shall be distinctly and permanently marked with the quantity of agent contained, the empty cylinder weight, the pressurization pressure and the zones they are protecting.
- The seamless cylinders shall be UL / Vds / FM apart from PESO approval.

11.3 Cylinder Valve

- The Valve assembly should be UL / Vds / FM approved and be mounted directly on the cylinder and should NOT have any adaptor in between the cylinder and Valve as per PESO requirements PESO license copy to be submitted by Contractor.
- Each cylinder valve shall have a provision for fixing a supervisory pressure switch and a safety burst disc to protect the cylinder from over pressure.
- Each valve is to be fitted with a pressure gauge for monitoring loss of pressure. The master cylinder valve is to be released electrically which is performed by means of a solenoid valve arrangement. The Electric actuation unit shall with manual lever assembly shall be UL / Vds / FM/ approved.

11.4 Cylinder valve Actuators / Electric Actuator with Placement Indication Switch

- In a single cylinder system, the cylinder shall have a UL / Vds / FM approved solenoid operated actuator and a manual actuator. Multi cylinder systems shall have the same fitted on to the master cylinder and pressure operated actuators

fitted on each slave cylinder. All actuators shall be UL / Vds / FM approved from OEM and locally manufactured actuators shall not be used.

- UL/ VDS Listed Cylinder Low Pressure Switch s per specification/drawings and as directed by PMC/Employer.
- UL/ VDS Listed Cylinder Discharge Pressure Switch, Shall be install on the piping after discharge hose as per specification/drawings and as directed by PMC/Employer.
- UL/ VDS Listed Pneumatic Actuator Shipping Assembly with actuation hose & Elbow as per specification/drawings and as directed by PMC/Employer.
- UL/ VDS Listed Local Manual Actuator as per specification/drawings and as directed by PMC/Employer .
- Electrical Actuator with placement indicator switch for Master Cylinder as per NFPA requirement and as per specification/drawings and as directed by PMC/Employer.

11.5 Discharge Hoses

- UL/ VDS Listed Discharge hose with Manifold Check Valve (Check Valve if More than one Cylinder in Bank) for above Cylinders, complete with Listed Adapters & Accessories as required as per specification/drawings and as directed by PMC/Employer.
- Each cylinder valve shall be provided with a plug-in type discharge hose of with a test pressure of minimum 52 Bar. Multi cylinder systems shall have an interconnect hose for each cylinder. All hoses shall be UL / Vds / FM approved from OEM and locally manufactured hoses shall not be used.

11.6 Check valves

- UL/ VDS Listed Discharge hose with Manifold Check Valve (Check Valve if More than one Cylinder in Bank) for above Cylinders, complete with Listed Adapters & Accessories as required as per specification/drawings and as directed by PMC/Employer.
- For Multiple cylinder systems, the manifold shall be fabricated at site with ASTM A106 Schedule 40 seamless pipe with ports provided to connect the check valves. The check valves shall be UL / Vds / FM approved. The check valves shall be threaded to the manifold on one end and discharge hose from cylinder on the other end. The manifold shall be fabricated based on the shop drawing from OEM.

11.7 Nozzles

- UL/ VDS Listed Nozzles, 360 Deg / 180 Deg Throw, selection as per approved hydraulic flow calculations. The sound pressure developed by discharge of total number of nozzles in each area needs to be submitted considering the distance between server rack and nozzle distance as 1 mtr. Software calculations for sound pressure to be submitted. - as per specification/drawings and as directed by PMC/Employer.

11.8 Re-Filling & Maintenance

- In case of any leakage or accidental discharge of the agent, it should be possible to re-fill the cylinders from a UL / Vds / FM approved filling station and also having a valid PESO approved OEM filling station in India itself. The contractor should indicate the source of re-filling and the time that will be taken for re-filling and replacement.

11.9 Pipe & Fittings

- Piping & Manifold as required, Sch 80; ASTM A106 Gr B, as per flow calculations for the specific hazard volume and stand to hold, position & Support the Manifold and Piping properly including Pressure testing for piping with nitrogen as per NFPA 2001 as per specification/drawings and as directed by PMC/Employer.
- Manifold fabricated out of Sch 80 pipe with 150 mm pipe with 11 port main and 11 port standby cylinders. The Manifold should include all the support and fittings.
- Seamless Pipe Sch 40 distribution pipe along which shall include all the support and fittings for pipes like U Clamps, Elbows, Sockets, Reducers, Tees, Flanges, Fasteners etc. for pipes for 7 cylinder system as per specification/drawings and as directed by PMC/Employer. piping shall be ASTM A-106, Grade-B, Schedule 40 seamless pipes and all fitting shall be of ASTM A-105.

11.10 Gas Release Panel

- Gas Release Panel shall be UL / Vds / FM approved with 8 hrs battery backup. Manual Release Switch and Manual Abort switch in conformance to the requirements put forth in NFPA 2001 shall be provided.
- UL/ VDS/ FM listed single zone gas release panel facility to connect manual abort/ release switch. The panel shall provide potential free contacts for first knock, second knock, trouble/ fault/ VDS status. The Panel shall be including 2 Core x 1.5 mm², Multistranded AT Copper, ZHFR Armoured cable, RED in Colour. The cable shall be laid on surface with GI saddle-spacers every 0.3 meters. Complete with GI Junction Box, lugs, cable compression glands, cable tags and Ferruling, required fittings, jointing, bracing, clamping, fastening. The panel shall be complete red color housing, monitored power supply unit, battery charger and batteries as per specification/drawings and as directed by PMC/Employer.

11.11 Manual abort Station

- Manual abort stations shall be fitted with transparent hinged covers to avoid possibility of accidental operation. The abort will be monitored simultaneously by the fire alarm or BMS system as per specification/drawings and as directed by PMC/Employer.

11.12 Manual abort Station

- Manual release station, shall be fitted with transparent hinged covers to avoid possibility of accidental operations. The Release switch shall be monitored

simultaneously by the fire alarm or BMS system as per specification/drawings and as directed by PMC/Employer.

11.13 Warning Sign Boards

- Warning Sign Board of size 150mm X 400mm with Marking "GAS DISCHARGE. DO NOT ENTER". Shall Operate on 24 V DC, Driven Through Gas Release Panel. (for use outside room) as per specification/drawings and as directed by PMC/Employer .
- Warning Sign Board of size 150mm X 400mm with Marking "GAS DISCHARGE. EVACUATE IMMEDIATELY". Shall Operate on 24 V DC, Driven Through Gas Release Panel. (for use inside room) as per specification/drawings and as per specification/drawings and as directed by PMC/Employer.

11.14 Documentation

- The system engineering company should prepare & submit along with the bid documents, the piping Isometric drawing and support the same with a UL / Vds / FM approved hydraulic flow calculation generated using the agent's design software. The calculations shall validate the fill density assumed by the Contractor.
- The Contractor shall submit copies of datasheets of UL / Vds / FM approved hardware used in the system. The Contractor shall also submit copy of PESO approval letter for the cylinder proposed to be used.
- The Contractor shall also submit calculations to evidence the qty of agent considered for the system.
- The successful vendor must submit, along with the supply invoice, a certificate of authenticity for the agent, duly checked and vetted by the OEM.
- The system engineering company should provide, as part of the handing over, the As-built drawings and operation & maintenance manual.

12.0 FIRE EXTINGUISHER SYSTEM

a. General Requirements:

- Fire extinguishers shall be worked out in such a way that the Occupants shall not travel more than 10m and 15m to reach a Fire extinguisher as per IS 2190:2010
- There shall be a Fire extinguisher for every 200 sq.m of floor plate / rooms / Shops of suitable type / size.
- Extinguishers shall be provided at surface car parks, AHU room, Lift machine room, lobby, corridor reception, server room, electrical installations and on the landing of each staircase of all floors etc as per drawings
- Operating instruction shall be pasted on the extinguisher body.
- Portable fire extinguishers shall be BIS approved and valid ISI certificates to be furnished at the time of delivery to site.

- Stand for fire extinguisher.
- All Fire Extinguisher shall be IS marked.

b. Handheld Fire Extinguishers

- Hand fire extinguishers shall be enamel alloy steel cylinder, provided with a trigger or seat type valve-locking pin or a seal and discharge horn.
- Contents of the extinguisher may be carbon dioxide, dry powder, water gas pressure, or foam, depending on fire class and storage location. Contents shall be such that no poisonous fumes or dangerous acids will be produced in any case.
- Size and type of hand fire extinguishers shall be subject to approval by the Local Authority.
- Fire extinguishers shall be bright red finished and provided with labels indicating dates of filling and renewal.

12.1 Carbon Dioxide (Co2) type Fire Extinguisher

- The Carbon Dioxide Extinguisher shall be as per IS: 15683:2018
- The discharge mechanism shall be through a control valve conforming to IS:3224. The internal siphon tube shall be of aluminium conforming to relevant specifications.
- The discharge horn shall be of high-quality unbreakable plastic with gradually expanding shape, to convert liquid carbon dioxide into gas form.
- The handgrip of Discharge horn shall be insulated with Rubber of appropriate thickness.
- CO2 High Pressure Portable 3 & 4.5 kg Fire Extinguisher, filled with Co2 Gas as per IS 15222, Gross Weight 16.4, empty weight 11.9 Kg, Control discharge mechanism fitted with 1 Meter Wire Braided Hose & Flat Horn with Diffuser Nozzle for dispersed discharge of CO2, Discharge Time 12 Sec, Average Discharge is 95%, Applicable on Class B, C and electrically started Fire, Fire Rating 55B, Internal coating is not applicable & External coating is of enamel spray painting, Powder Coated Handle, Valve Confirm to IS 3224 ISI Marked, CO2 Cylinder construction: hot spinning by seamless pipes & bearing ISI mark, Body confirms to IS 7285 and PESO APPROVED, Extinguishers confirmed to IS 15683:2018 and ISI marked.
- It shall be an Upright type. The cylinder, including the control valve and high-pressure Discharge Hose must comply with relevant Statutory Regulations, and be approved by Chief Controller of Explosives, Nagpur and also bear IS marking. The Extinguisher including components shall be IS marked.

12.2 Water Type Extinguisher (Gas Pressure Type)

- The Extinguishing medium shall be water stored pressure type, with expelling agent Nitrogen.

- The capacity of Extinguisher, when filled upto the indicated level, shall be 9 ltr +/- 5%
- The skin thickness of the Cylinder shall be made up from 2.0mm sheet, fabricated from Mild Steel sheet, MIG welded of top & bottom.
- Gross Weight 12 Kg, empty weight 4.3 Kg, Can Height 575mm, Diameter 180 ± 10mm, Discharge Time 35 Sec, applicable on Class A, Fire Rating- 3A.
- The neck shall be internally threaded up to a minimum depth of 16 mm, and of mild steel.
- Squeeze grip valve of forged Brass & NRV at pressure gauge mounting port, screwed on the body up to a minimum of 1.6 cm depth, with parallel screw thread to match the neck ring.
- The siphon tube to be of PVC. Stainless steel safety pin.
- The discharge hose shall be Rubber braided EPDM hose (Burst pressure ≥ 55 bar) with Aluminum crimping, of 12.5 mm dia. and 560 mm long, with aluminum nozzle.
- The extinguisher shall be treated for anti-corrosion internally and externally, and externally Phosphate treatment followed by powder coating of body DFT not less than 50 Micron & Internally plastic coating with finish of PO Red as per IS: 5 (Shade 538).
- The paint shall be powder coated.
- The extinguisher, body and cap shall be treated to an internal hydraulic pressure of 35 Kg/cm².
- It shall have external marking with letter A, of 2.5 cm height, in block letters.
- The extinguisher shall be upright in operation, with the body placed on ground and discharge tube with nozzle held in one hand to give a throw Minimum 2 mtr and continue so for at least 13 secs.
- The extinguisher body shall be clearly marked with ISI stamp (IS 15683:2018).

12.3 ABC Type Dry Powder Extinguisher

- The Extinguisher shall be filled with Mono Ammonium Phosphate 90% from any approved manufacturer.
- The capacity of the extinguisher when filled with Dry Chemical Powder (First filling) as per IS 4308, Part II, shall be 6 Kg +/-2% or 9 Kg +/- 3%.
- The distribution of fire extinguishers to be as per IS 2190 – 1992. It shall be operated upright, with a squeeze grip valve to control discharge.
- It shall be pressurized with Dry Nitrogen, as expellant.
- The Nitrogen to be charged at a pressure of 15 Kg/cm². Body shall be of mild steel conforming to relevant IS Standards.
- The neck ring shall be also mild steel and welded to the body. The discharge valve body shall be forged brass & NRV at pressure gauge mounting port, Stainless steel Safety pin, and siphon tube shall be of PVC.

- The nozzle shall be of PVC, while the hose shall be Rubber braided EPDM with aluminum crimping. The body shall be cylindrical in shape, with the top and bottom welded to it.
- Sufficient space for Nitrogen gas shall be provided inside the body, above the powder filling.
- The Neck Ring shall be internally threaded - the threading portion being 1.6 cm. The filler opening in the neck ring shall not less than 19 mm.
- ABC Type Fire Extinguisher Cap. 6 kg Filled with Mono Ammonium Phosphate Powder 90% confirms to IS 4308, Stored Pressure Type, UGTS Pressure Gauge, Gross Weight 8.9 Kg, Empty Weight 2.9 Kg, Can Height 530 mm, Diameter 150 ± 10 mm, Discharge Time 24 Sec, Controllable discharge mechanism, Jet Range 5 Meters, Average Discharge is 92%, applicable on Class A,B & C and electrically started Fire, Fire Rating 6A:183B, Can Construction : Deep drawn & MIG welded, EPDM Rubber Hose with both end Aluminum crimped, Internal & External - Pure Polyester Powder coating (UV Resistant), Brass forged valves with safety Pin is of SS material, Made up from 1.6mm thick sheet, ISI Approved IS 15683:2018.
- ABC Type Fire Extinguisher Cap. 9 kg Filled with Mono Ammonium Phosphate Powder 90% confirms to IS 4308, Stored Pressure Type, UGTS Pressure Gauge, Gross Weight 13.9 Kg, Empty Weight 4.9 Kg, Can Height 575 mm, Diameter 180 ± 10 mm, Discharge Time 31 Sec, Controllable discharge mechanism, Jet Range 5 Meters, Average Discharge is 92%, applicable on Class A,B & C and electrically started Fire, Fire Rating 6A:233B, Can Construction : Deep drawn & MIG welded, EPDM Rubber Hose with both end Aluminum crimped, Internal & External - Pure Polyester Powder coating (UV Resistant), Brass forged valves with safety Pin is of SS material, Made up from 2mm thick sheet, ISI Approved IS 15683:2018
- It shall have a pressure gauge fitted to the valve assembly or the cylinder to indicate pressure available inside.
- The extinguisher shall be treated with anti-corrosive paint, and it shall be labeled with words ABC 2.5 cm long.
- The extinguisher body and valve assembly shall withstand internal pressure of 35 Kg/cm² for a minimum period of 2 minutes.
- The pressure gauge shall be imported and suited for the purpose.

12.4 Mechanical Foam Type Extinguisher

- The construction of body shall be welded, and the requirement of thickness of sheet and details of the construction shall be as per IS:16018.
- The charge shall be of mechanical foam compound as per IS-4989-1974 (part-11 AFFF) The fire extinguisher shall be painted ' PO RED ' conforming to shade No 538 of IS- 5-1961.Each fire extinguisher shall be clearly marked with necessary information in English.
- Mechanical Foam type 45 ltr. Fire Extinguisher, Applicable fire class A & B, Can Height 1200mm, Diameter 300 mm, Controllable Discharge mechanism,

Discharge Time min. 30-180 Sec, Jet Range 8 Meters, Average Discharge is 95%, Fitted with EPDM Hose with SS spring of 300mm to avoid kink (4 meter long) & Air aspirated Nozzle, CO2 gas Cartridge of 300 grams. Confirms to IS 4947, Internal & External Pure polyester (UV Resistant) powder coated, Brass forged cap, and Welding Procedure approved by TPI with 6G certification. Conforms to IS 16018:2012, Fire rating 20A:233B.

12.5 Bucket

- Design as per IS: 2546.
- Floor mounted bucket stand with GI buckets to hand 4 nos. of 9 ltrs buckets sand filled.
- The stand shall be 5'(L) x 3'(H) x 2"(W) made out of 30 x 300 x4mm MS angle frame duty coated with 2 coats of red oxide primer & 2 coats of red finish paint
- Made out of heavy duty G.I. of gauge 18 to 20 SWG
- Handle at the bottom for easy handling while usage
- Bottom of bucket - hemispherical
- Finishing - Painted
- Outside of the Fire Bucket shall be painted with 2 coats of red oxide primer & 2 coats of red finish paint. The word FIRE shall be written outside the bucket in highly visible colour. The inside of the Fire Bucket shall be painted with primer and white

12.6 Wet Chemical Stored Pressure Type Fire Extinguisher

- ISI Marked Wet Chemical Stored Pressure Type Fire Extinguisher, Capacity 2L, Fire rating 15F, Deep drawn cylinder body with Metal Skirt, Squeeze Grip CE marked Valve made of forged brass with nickel chromium plating and Stainless Steel Carrying and Operating Handles.
- Aluminium Siphon Tube, Brass Nickel Chrome-plated nozzle, PET material label with UV resistant ink, QR code for product traceability.
- Testing and Inspection - As per IS 15683:2018.
- F Class Kitchen Wet chemical (Blend of Potassium Acetate, Potassium citrate or Potassium carbonate) 3 ltr. Fire Extinguisher, Smooth and Polished Stainless Steel body, Applicable fire class K, UGTS Pressure Gauge, Gross Weight 5.3 Kg, empty Weight 2.3 Kg, Can Height 500mm, Diameter 140 ± 10mm, Discharge Time 14 Sec, Controllable discharge mechanism, Jet Range 3.5 Meters, Average Discharge is 95%, Controllable discharge mechanism with EPDM Hose & Specially designed Nozzle that allows a broad, dispersed discharge of agent that delivers a high volume, low velocity delivery of wet chemical which doesn't cause the cooking oil to splash. CE Marked Valve with inbuilt NRV & Safety Release Provision and safety Pin is of SS material, Sheet metal thickness: 0.9 to 1 mm. Confirms to IS 15683 & ISI marked & CE Marked.

12.7 Clean Agent Type Fire Extinguisher

- 2 kg Fire Extinguisher UL listed FE-36 (HFC-236 fa) gas Electrically nonconductive, non corrosive, colorless and non-residual clean agent Suitable for Class A, B, C, and electrical fires approved with US EPA (Environmental Protection Agency), listing under USA Signification New Alternative Policy (SNAP) & also approved by (Environmental Protection Agency) listing under USA Signification New Alternative Policy SNAP) & also approved by UL, compliant with ASTM -D6541-11. low toxicity, also its replacement for Halon 1211, Halon 1201. Controllable discharge mechanism with EPDM Discharge Hose with Specially designed Unique Nozzle, UGTS Pressure Gauge, Body Construction Deep Drawn with MIG Welding technology, External Pure polyester and Internal Epoxy polyester powder coated, Brass forged CE marked valves with safety pressure release mechanism, safety Pin is of SS material, and Welding Procedure approved by TPI with 6 G certification. Fire Class 1A:21B rating as per IS 15683 and ISI MARK.

12.8 Ceiling Mounted Clean Agent Type Fire Extinguisher

- Automatic type 5 kg Fire Extinguishers "Chemours" Make UL listed FE-36 (HFC-236 fa) gas which is Electrically nonconductive, non corrosive, colorless and non-residual clean agent Suitable for Class A, B, C, and electrical fires approved with US EPA (Environmental Protection Agency) , listing under USA Signification New Alternative Policy (SNAP), & also approved by UL , compliant with ASTM -D6541-11. FE-36 Fire Extinguishers having Zero Ozone Depletion Potential (ODP), low toxicity, also ts replacement for Halon 1211, Halon 1201, UGTS Pressure Gauge, Empty Weight 2.64 kg, Full weight 7.64 kg. Can Height 370mm, Diameter 230 ± 10mm, Made up from 2 mm thick sheet,, Body Construction Deep Drawn with MIG Welding technology, External Pure polyester and Internal Epoxy polyester powder coated, Brass forged sprinkler valves, Heat Sensitive Glass bulb of 68 ° C. Area covered will be 5.3 m2 and volume of coverage is 6 m3.

13.0 EQUIPMENT & SERVICES TO BE PROVIDED BY THE CONTRACTOR FOR INSTRUMENTATION & CONTROL SYSTEM FOR FIRE PROTECTION SYSTEM**13.1 The following shall be in the scope of the CONTRACTOR.**

- Supply, installation & commissioning of complete instrumentation system for the fire protection system including field instruments, the system control panel, panel mounted instruments and devices, all instrument erection hardware including instrument impulse lines, fittings and valves, necessary junction boxes, shall be supplied installed and commissioned by the CONTRACTOR.
- Supply, installation & commission of completely wired system control panel including all panel mounted instruments and devices as per specification.
- Supply, installation & commissioning of all cables for the system including cables from UPS & MCC to the Control Panel including glanding & termination of cables, cable trays along with lugs, ferrules, cable tray supports and other cable laying accessories.

- Complete loop checking of all measurement & command chains provided by Contractor.
- The Contractor shall ensure and supply all erection hardware required for installation of all instrumentation, which form part of this package. This includes items like, mounting accessories, tubing, tube fittings, pneumatic signal tubes, identification tags, structural material required for instrument support etc.
- Supply of all necessary tools, tackles, test & calibration instruments and experienced personnel for completion of the above erection, testing and commissioning works.
- All instruments required for performance testing to prove the guaranteed performance of the equipment supplied shall be loaned to the PMC / Employer by the Contractor at no extra cost for the duration of the performance test. These test instruments shall have test certificates from reputed test house, (traceable to standards) valid for the duration of the performance test.

13.2 Indications, Controls & Interlock

- All the transmitters input, important & critical parameters shall be indicated on front facia of local control panel. All controls and interlocks shall be achieved in local control panel.
- All the interlock shall be provided as per Fire Protection Schematic Diagram and as per specification.

13.3 Instrument Configuration

- All instruments shall be suitable for use in hot, humid & dusty climate. All instruments, their supports including all mounting hardware, manifolds, and fittings shall be suitable for the application. All external surfaces shall be suitably treated to provide protection against the atmosphere.
- Wherever the service is hazardous, the field transmitters shall be intrinsically safe. For switches, JB's, LPB's suitable ex-proof enclosure shall be provided in hazardous areas.
- The performance of all instruments shall be unaffected for the variation in voltage and frequency of the power supply.
- Enclosures of field transmitters and switches shall be die cast aluminium with epoxy painting as a minimum.
- All panels, control desks, field instruments, JB's, LPBS & enclosures shall comply with the requirements of protection classes as indicated below

In-door Air-conditioned (A.C.) areas -	IP 20
In-door Non A.C. areas	IP 52
Outdoor areas	IP 65
Submersible application	IP 68

- The power supply for the instrumentation & control system shall be 24 V DC, unless otherwise specified.

- All instruments mounted outdoors shall be provided with FRP canopy for protection from top & sides.
- All instruments shall be provided with SS tag plate.

13.4 System Control Panel

- A hardwired relay-based control panel shall be provided in the fire water pump house for operation & monitoring of the fire protection system.
- Control panel specifications.

Sr No	DESCRIPTION
1	Type of Control System: Relay based
2	Local Control Panel: Skid mounted / free standing
3	Selector switches push buttons and indicating lamps on front facia of panel: Required
4	Alarm Annunciation: Annunciated on panel mounted alarm annunciator with separate audio hooter.
5	Hooter: For audio Alarm condition. Facility for the Test / Acknowledge / Reset for Alarms shall be provided.

- The following switches, indicating lamps and push buttons shall be provided on the front facia of System Control Panel:
 - Auto / Manual selector switch for each Electric Motor Driven main fire water pumps and Jockey pumps for the fire hydrant network.
 - Auto / Manual selector switch for each Electric Motor Driven Main fire water pumps and Jockey pumps for the fire hydrant system.
 - Main / standby selector switch for electric motor driven standby pumps
 - Main / standby selector switch for fire water pump system for the all fire system.
 - Auto / Manual selector switch for each Electric Motor Driven booster pumps
 - Start and stop push button for each pump.
 - Pump ON indicating lamp for each jockey pump and main fire water pump.
 - Digital panel water tank level indicator for each compartment of fire water tank.

- The logic for pump operation for Hydrant system shall be as follows (Please refer Fire schematic pressure setting table)

Auto mode

- In case of leakages in the system, the system pressure maintained at 12 kg/sq.cm (g) will drop gradually. When the pressure drops by 0.35 kg/sq.cm(g) (i.e. system pressure- 11.65 kg/sq.cm) , jockey pump (JP-1) shall start automatically through the actuation of pressure switch (PS-01 @ 11.65 kg/sq.cm) . The jockey pump (JP-1) shall stop automatically through the actuation of pressure switch (PS-01 @ 12 kg/sq.cm) when the pressure is restored to system pressure. Jockey pump (JP-2) will start automatically through the actuation of pressure switch (PS-02 @ 12 kg/sq.cm) due to fail to start of jockey pump (JP-1).

- b. In the event of hydrant valve opening, the system shall come into operation. Since the water demand shall exceed the pumping rate of jockey pump, it will be unable to restore the system pressure. When the pressure drops by 2 kg/sq.cm (g) (ie. system pressure – 9.30 kg/sq.cm) the motor driven main fire pump shall start automatically through the actuation of a pressure switch ((PS-03 @ 9.30 kg/sq.cm). Engine Driven pump (DHP-1) will start automatically through the actuation of pressure switch (PS-07 @ 6 kg/sq.cm) due to fail to start of Hydrant Pump (HP-1).
- c. If main fire pump fails to start within 15 seconds and the pressure in header drops by 6 kg/sq.cm(g)) (ie. system pressure – 6 kg/sq.cm) the Engine Driven pump (DHP-1) shall start automatically by the actuation of pressure switch(PS-07 @ 6 kg/sq.cm).
- d. The stopping of pumps main fire pump and engine driven shall be manual.

Manual mode

In the manual mode, the motor operated fire water pump & jockey pumps shall be started/stopped using pushbuttons provided on the LPBS/ MCC. For the engine driven pump, start & stop shall be done using pushbuttons on the diesel engine local control panel.

The logic for pump operation for sprinkler system shall be as follows

- a. In case of leakages in the system, the system pressure maintained at 12 kg/sq.cm (g) will drop gradually. When the pressure drops by 0.35 kg/sq.cm(g) (i.e. system pressure- 11.65 kg/sq.cm) , jockey pump (JP-1) shall start automatically through the actuation of pressure switch (PS-01 @ 11.65 kg/sq.cm) . The jockey pump (JP-1) shall stop automatically through the actuation of pressure switch (PS-01 @ 12 kg/sq.cm) when the pressure is restored to system pressure. Jockey pump (JP-2) will start automatically through the actuation of pressure switch (PS-02 @ 12 kg/sq.cm) due to fail to start of jockey pump (JP-1).
- b. In the event of sprinkler burst, the system shall come into operation. Since the water demand shall exceed the pumping rate of jockey pump, it will be unable to restore the system pressure. When the pressure drops by 2 kg/sq.cm (g) (ie. system pressure – 8.30 kg/sq.cm) the motor driven main fire pump(SP) shall start automatically through the actuation of a pressure switch(PS-04 @ 8.30 kg/sq.cm).
- c. If main fire pump fails to start within 15 seconds and the pressure in header drops by 6 kg/sq.cm(g)) (ie. system pressure – 6 kg/sq.cm) the Engine Driven pump (DHP-1) shall start automatically by the actuation of pressure switch(PS-07 @ 6 kg/sq.cm).
- d. The stopping of pumps main fire pump and engine driven shall be manual.

Manual mode

In the manual mode, the motor operated fire water pump & jockey pumps shall be started/stopped using pushbuttons provided on the LPBS/ MCC. For the engine driven pump, start & stop shall be done using pushbuttons on the diesel engine local control panel.

13.5 Alarms to be Annunciate On Control Panel

The list of alarms indicated are the minimum requirement. Any additional alarms required for safe and efficient operation of the system shall be provided by vendor without any extra cost.

Sr. no.	Alarm description
1.	Jockey Pump Hydrant (JP) running
2.	Jockey Pump Hydrant (JP-1) fails to start
3.	Jockey Pump Hydrant (JP-1) fails to start
4.	Jockey Pump Hydrant (JP-1) in manual mode
5.	Jockey Pump Sprinkler (JP-2) running
6.	Jockey Pump Sprinkler (JP-2) fails to start
7.	Jockey Pump Sprinkler (JP-2) trip on overload
8.	Jockey Pump Sprinkler (JP-2) in manual mode
9.	Main Pump Hydrant (HP) running
10.	Main Pump Hydrant (HP) in manual mode
11.	Main Pump Hydrant (HP) failed to start
12.	Main Pump Sprinkler (HP) running
13.	Main Pump Sprinkler (HP) in manual mode
14.	Main Pump Sprinkler (HP)) failed to start
15.	Diesel Engine Pump Hydrant (DHP-01) running
16.	Diesel Engine Pump Hydrant (DHP-01) fail to start.
17.	Diesel Engine Pump Hydrant (DHP-01) in manual mode
18.	Diesel fuel tank level low for (DHP-01)
19.	Diesel Engine Pump Hydrant (DHP-01) Battery charge failure
20.	Low pressure in discharge header of the system
21.	Level Switch – High water level
22.	Level Switch – Low water level
23.	230 VAC to 24 VDC power supply unit 1 tripped
24.	230 VAC to 24 VDC power supply unit 2 tripped

25.	Engine diesel fuel tank level low
26.	Battery Charge Failure
27.	Main header pressure high
28.	10% spare alarm windows

14.0 FIRE STOP SEALANT

Fire stop mortar system with minimum 2 hours fire rating when tested in accordance with UL 1479/ASTM-E 814 standards, for horizontal openings in floors or slabs after passing service lines like Metal/Plastic Pipes, HVAC Duct with combustibel/Non Combustible insulations. The mortar shall be a light weight cementitious product and shall carry test certificate in accordance with IEC 60068-2-57:1999-11 (Environmental Testing) as per Part 2-57: Test for Vibration-Time-history method for seismic zone 3. The product shall be age tested as per Dafstb and DIBT standards. The product shall carry test certificate for mold resistance rating of 0 as determined by ASTM G21-96. The system shall be UL listed & classified and product shall bear the UL and FM approval logo on the packing. A firestop submittal shall be produced by manufacturer , in accordance with approved passive fire protection method statement, for technical approval. Firestop installation shall be done by supplier Accredited Firestop Speciality Contractor or by certified installers inline with UL system test certificates. Firestop Speciality Contractor needs to submitt work completion certificate along with installation report with supplier warranty certificate for periodic inspection & maintenance purpose. The gaps around combustible penetrants like plastic pipes or ducts with insulation shall be sealed with an appropriate material as recommended by the supplier.

High performance intumescent Firestop sealant that helps protect combustible penetrations for up to 2 hours fire rating in accordance to UL 1479 (American) standards. Surface burning characteristics according UL 723 (ASTM E84-96). Flame spread index 0 and smoke development index 5. Movement capability approx.. 5% (ISO 11600) and the average volume shrinkage is 24% according ASTM C1241meeting LEED requirements for indoor environmental quality credit (4.1 and 4.2) with a VOC content of 9 g/l. product should also Seismic tested on mechanical performance, smoke and fire-ratings.

15.0 ELECTRICAL

Refer Electrical Specification Section

16.0 CHAIN BLOCK PULLEY

Triple Spur Gear, Top & bottom hook with safety latch hand hoist, 3 Ton capacity, Swivel for Top & Bottom block.

*Load chain 10mm, length = (2X 3+0.45) Mtr.

*Hand chain 5mm, length = (2X 3+0.45) Mtr.

CERTIFICATION: All the chain blocks should be tested to a proof load of 1.5 times the working load limit. It should be light weight & sturdy for ease of handling. Chain pulley blocks must confirm to IS 3832 and Safety approval from reputed national / international agencies along with test certificate & reference of reputed user.

16.1 REFERENCES OF CODES AND STANDARDS:

The latest editions of following code and standards shall be followed:

- IS:3832 - Specification for hand operated chain pulley blocks.
- IS:2429 (Part-II) - Specification for round steel short link chain.
- IS:6216 - Specification for short link chain, grade T (8) calibrated.
- IS:8610 - Point hooks with shank capacity upto 25 Tones Trapezoidal section.
- SIS:055900 - Swedish Standard for sand blasting.

16.2 TECHNICAL REQUIREMENTS

Design & manufacture of Mono Rail Geared Trolley (Manually operated) with chain pulley block should meet the specified requirements; i.e. capacity, head room, lift and other parameters as specified in BOQ and care shall be taken to have following features:

- Minimum efforts to lift a specified load.
- Self braking system for holding the load in any position.
- Even loading of bearings.
- Ease of installation and maintenance.
- Compact design. All materials used in construction of different components shall conform to the relevant standards. The materials for non-lubricated rubbing parts shall be of non-sparking type (non-ferrous).

The suggested materials for such components are as follows:

- a. Ratchet wheel, load chain wheel, hand chain wheel, chain guides for lifting mechanism. Phosphor bronze or gun metal.
- b. Rims of un-gearred runners, geared runners, hand chain wheel & hand chain wheel guides for trolley mechanism.: Phosphor bronze or gun metal.
- c. Load hooks : Forged brass or aluminium.

16.3 FRAME

The frame shall be designed for proper strength built from steel plates with bolted/ welded construction.

16.4 GEAR

Chain pulley blocks shall be supplied with helical or worm gear. The gear shall be designed for surface durability. All gears shall be machine cut from alloy steel and case hardened. In case of enclosed gearing, means shall be provided for ample lubrication.

16.5 LOAD BREAKS

Chain pulley block shall be provided with an automatic mechanical load brake; ratchet and pawl type to prevent self lowering of the load and arrest as well as sustain the load in all working positions. The load brake shall also allow smooth lowering of the load without serious over heating as it may impair efficient working of the chain pulley block.

The pawl & ratchet should be made of steel; hardened and tempered to provide satisfactory degree of wear resistance. The hardness of pawl tip and ratchet shall not be less than 40 and 30 HRC respectively.

16.6 BEARINGS

Only anti friction bearing shall be used. All the bearing shall be adequately lubricated type and arrangement of lubrication shall be clearly indicated on the cross section drawings. Bearings of reputed make like SKF / FAG / NTN shall be used. Provision shall be made for service lubrication of all bearings. Bearings enclosures shall be designed as far as practicable to exclude dirt and prevent leakage of grease.

16.7 HOOKS

i) The hooks (top and bottom) shall conform to IS:8610. The bottom hook block shall be provided with a thrust bearing to enable it to have free swivel in the loaded condition without twisting the load chain. The top hook, if required to swivel shall also be provided with thrust bearing.

ii) Ball and roller bearings shall not be used in the hooks.

iii) Hooks shall be provided with a safety latches to prevent accidental unhooking.

iv) Suspension fitting other than hook shall be of sufficient strength and its static factory of safety should not be less than 4.

16.8 LOAD CHAIN

The load chain links should be of minimum grade 80 conforming to IS:6216. The chain shall be pitched and polished.

16.9 HAND CHAIN

The short link hand chain shall be conforming to grade 30 to IS:2429 (Part I). The chains shall be pitched & polished. The chain link dimension shall be conforming to 6.3mm nominal diameter chain of IS:2429 (Part-I). The length of chain shall be such that the lowest point of loop shall be 0.4 metre above the operating level.

16.10 CHAIN WHEEL

Wheel for load chain shall be made of material suitable for use with load chain employed and be of adequate strength and shall be designed to ensure effective operation. Wheel for hand chain shall be provided with flange. Wheel for hand chain shall be provided with chain guards to retain the chains in grooves and chain should not come out of the groove. Wheels shall be provided with guides to prevent sagging of chain.

16.11 IDLER WHEEL

The chain pulley blocks shall be provided with idler wheels so shaped as to avoid twisting of the chain when passing round. The pitch diameter of the idler wheels shall not be less than 16 times of size of the chain.

16.12 TROLLEY

The trolley for the chain pulley block shall be of geared type, fabricated construction, 4-wheeled, driven by hand chain and shall have provision for mounting the chain pulley block.

Trolley shall be designed to suit the suitable joint size and the hoisting capacity.

Trolley frame plates should be made from heavy section of rolled carbon steel; rigidly held together by means of bolts and designed to eliminate distortion at rated capacity.

The driving and driven wheels should be identical and of solid construction. The threads of the wheels should be suitable to the profiles of standard beams.

Adjustment in trolley should be possible to enable trolleys to be used on beams of different width by adjusting spacers on both sides of the trolley side plates.

16.13 PROTECTION AND PAINTING

All exposed carbon steel parts to be painted shall be thoroughly cleaned from inside and outside to remove scale, rust, dirt and other foreign materials by wire brushing and blasting as applicable. Minimum acceptable standard in case of power blast cleaning shall be St. 3 and in case of blast cleaning shall be Sa 2½ as per Swedish Standard SIS:055900.

Non-ferrous material, austenitic stainless steels plastic or plastic coated materials, insulated surfaces of equipment and pre-painted items need no painting.

Stainless steel surfaces both inside out side, shall be picked and passivated. Machined and bearing surfaces shall be protected with varnish or thick coat of grease.

Depending on the environment, following primer and finish coats shall be applied.

- i. Normal industrial Primer: 2 coats of red oxide zinc chromate each 25 microns (min.) thick DFT. Finish coat: 2 coats of synthetic enamel, each 25 microns (min.) thick DFT.
- ii. Corrosion industrial Primer: 2 coats of Epoxy zinc chromate each 35 microns (min.) thick DFT. Finish coat: 2 coats of Epoxy high built paint each 100 microns (min.) thick DFT.
- iii. Coastal and Marine: Primer: 2 coats of high build chlorinated rubber zinc phosphate each 50 microns (min.) thick DFT. Finish coat: 2 coats of chlorinated rubber paint, each 35 microns (min.) thick DFT.
- iv. All environments (temperature 80 – 4000 C) Finish coat: 2 coats of heat resistant aluminium paint suitable for specified temperature each 20 microns (min.) thick DFT. All values of paint thickness refer to DFT (Dry Film Thickness). 3.11.6 The colour finish coat shall be intimated to vendor after placement of order.

16.14 INSPECTION & TESTING

Equipment shall be subjected to stage wise expediting, inspection and testing supplier's / sub-supplier's / sub-supplier's works by TIDEL / its authorized inspection agency. Supplier shall submit Quantity Assurance (QA) plan before commencement of fabrication as given in this specification duly signed as token of acceptance.

A certified record of test figures / results shall be submitted along with the equipment. If as a result of any inspection or test, TIDEL is of reasonable opinion that items do not comply with order; such items shall be rejected by TIDEL.

TIDEL / its authorized inspection agency's attendance to such inspection and/or tests shall not be interpreted as in any way to relieve supplier from any liability or responsibility for any defects which may be found during the guaranteed period.

Each chain pulley block shall be subject to one and a half times the safe working load through a length of lift which will ensure that every part of the block mechanism and each tooth of gears come under load. The trolley shall be tested for smooth operation when loaded.

Any or all the tests, at TIDEL's option, shall be witnessed by TIDEL / its authorized inspection agency. However, such inspection shall be regarded as check-up and in no way absolve the supplier of his responsibility.

A certified record of test results (works and site) shall be submitted along with the equipment. Test certificates of all site bought out components shall be provided.

For site testing, slings, test gauges and instruments shall be arranged by the vendor.

Certificate of test & examination shall be issued with all the chain pulley block giving following information:

- a) Safe working loads.
- b) Range of lift.
- c) Load chain size and grade.
- d) Proof load applied.

16.15 PACKING AND PRESERVATION

Attachments, spare parts packing shall be done in such a manner as to reduce the volume. The equipment shall be dismantled into major components suitable for shipment and shall be properly packed to provide adequate protection during shipment. All assemblies shall be properly match marked for site erection.

Attachment of spares of the equipment and small items shall be packed separately in wooden cases. Each item shall be approximately tagged with identification of main equipment, item denomination and reference number of the respective assembly drawing.

Detailed packing list in water-proof envelope shall be inserted in the package together with equipment.

Each equipment shall have an identification plate giving salient equipment data, make, year of manufacture, equipment number, name of manufacture etc.

16.16 PERFORMANCE GUARANTEE

The chain pulley block shall be guaranteed for the satisfactory performance at all operating conditions as per the data sheet. Acceptable tolerance on guaranteed characteristic shall be applicable as per IS / DIN / BS / ISO / Internal Standards.

Following chain pulley block parameters shall be guaranteed in specific: a) Safe working load capacity and lift. b) Satisfactory performance and smooth operation when loaded. c) Dimensional stability of all parts of chain pulley block.

All equipment, accessories, bought outs etc. supplied by the supplier shall be guaranteed for its performance and/or faulty design, fabrication, manufacturing etc. for a period of 18 months from the date of dispatch or 12 months from the date of commissioning whichever is earlier. Any item which fails during guarantee period shall be replaced by the supplier free of cost to the TIDEL. For replaced components, the guarantee shall be another 12 months after the installation of the replaced parts.

16.17 SPARES

Supplier shall include cost of all such spares in the offer of the equipment, which might be required during installation and commissioning of the equipment. A list of the spares shall be furnished along with offer.

Supplier shall submit his recommended list of spare parts with recommended quantities and itemized prices for first two years of operation of the equipment. Proper coding and referencing of spare parts shall be done so that later identification with appropriate equipment will be facilitated.

Recommended spares and their quantities should take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of supplier's service facilities around proposed location of equipment.

16.18 TECHNICAL DOCUMENTATION

The supplier has to furnish technical documentation as listed below (as minimum requirement of TIDEL):

- i. Data sheets to be filled by vendor and submitted to TIDEL for approval.
- ii. Engineering for beam size required for monorail trolley.
- iii. Quality assurance plan (format) to be filled and submitted by the supplier. for approval of TIDEL.
- iv. Monthly progress report.
- v. List of lubrication points, type & quantity of lubricant required.
- vi. Operation, erection and maintenance manual.
- vii. Complete GA drawing with overall dimensions, details of major items along with load data required for civil design etc.
- viii. List of bought-out items along with supplier's name and its specification. ix) List of wear / replaceable parts and guaranteed life thereof.
- ix. Material list and material specification / details of major items like gears hooks, chain block etc.

16.19 GENERAL NOTE

- i. Party shall enclose this specification sheet duly signed and stamped along with their offer as a token of acceptance, otherwise offer may be treated as incomplete or may not be considered/ rejected.
- ii. Party has to submit all related documents along with the supplied items.
- iii. All deviations are to be listed in a separate note entitled 'Technical Deviation'.

17.0 TESTING OF THE SYSTEM**17.1 Method of Testing System:**

Performance of Test results & notes on test instruments and capacity computation shall be as per **CPWD General Specifications for Electrical Works Part-V (Wet Riser & Sprinkler Systems) 2020** requirement.

The following tests shall be carried out for ensuring that the system and various components meet the system specifications.

Hydrant piping at basement and above floor.	As per CPWD specifications, All piping shall be tested to hydrostatic test pressure of at least one and a half times the maximum operating pressure i.e. $12 \times 1.5 = 18 \text{ kg/cm}^2\text{g}$, but not less than $18 \text{ kg/cm}^2\text{g}$ for a period not less than 24 hours. While Hydro Testing, inclusion of cut-off valves in the mains to be tested can be avoided. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Engineer-in-Charge. Leak test: system to be tested at maximum operating pressure for functional test at operating pressure for 24 hours after fixing all components. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the PMC/Employer
Fire water pump	Pump shall be capable of furnishing not less than 150% of rated capacity at a head of not less than 65% of the rated head. The shut off head shall not exceed 140% of rated head.
Diesel Engine	Shall be capable of operating continuously on full load at the site elevation for a period of six hours. Maximum noise level 85 db at 1.0 M from Eqpt. Outline
Wrapper coating on underground pipes	Holiday testing
Other components	As per data sheet / requirements specified.

All piping shall be tested to hydrostatic test pressure of 18 Kg/Cm^2 OR 1.5 times of design pressure, whichever is higher, for a period of not less than 2 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the PMC/Employer

Piping required subsequent to the above pressure test shall be re-tested in the same manner.

System may be tested in sections and such sections shall be securely capped.

The Engineer shall be notified well in advance by the Contractor of his intention to test a section of piping and all testing shall be witnessed by the PMC/Employer

The Contractor shall make sure that proper noiseless circulation of fluid is achieved through the system concerned. If proper circulation is not achieved due to air bound connections, the Contractor shall rectify the defective connections. He shall bear all the expenses for carrying out the above rectification including the tarring-up and re-finishing of floors, walls etc. as required.

The Contractor shall provide all materials, tools, equipment, instruments, services and labor required to perform the test, and shall ensure that the plant room and other areas are cleaned up and spill over water is removed.

The Contractor shall give the pressure test of head for hydrant at ground level and also for hydrant at terrace level.

All air shall be trapped from the pipeline through hydrants, Hose Reel & air valves. Each section of the pipe shall be slowly filled with the water & allow to stand the water for few hours with the ends closed.

Flushing of underground connections: Underground mains and lead-in connections to system risers shall be flushed before connections made to piping in order remove foreign materials which may have entered the underground during the course of installation. For hydrant system the flushing operation shall be continued until water is clear.

18.0 COMMISSIONING OF SYSTEM:

System commissioning shall be as per CPWD General Specifications for Electrical Works Part-V (Wet Riser & Sprinkler Systems) 2020 requirement.

Before commissioning, the entire system shall be flushed to ensure that any earth /foreign matters which might have entered during installation are taken out. For this, pump may be operated and valves opened at different locations.

As soon as the work is complete, the system shall be commissioned and made available for use. Requirement of fire Protection system installations is equally important during occupation of the building. If the building is to be occupied in part, fire Protection system of building completed shall be commissioned by isolating the system of under construction portion of the building.

The fire Protection system shall be maintained and manned from the very first day of its commissioning.

Any defects noticed during the warranty period shall be promptly attended by the Contractor and availability of the system at all times is to be ensured.

18.1 Acceptance Test:

At the time of taking over, the hydrant system shall fulfill the following acceptance tests:-

The logic for pump operation for Hydrant system shall be as follows.

- a. In case of leakages in the system, the system pressure maintained at 12 kg/sq.cm (g) will drop gradually. When the pressure drops by 0.35 kg/sq.cm(g) (i.e. system pressure- 11.65 kg/sq.cm) , jockey pump (JP-1) shall start automatically through the actuation of pressure switch (PS-01 @ 11.65 kg/sq.cm) . The jockey pump (JP-1) shall stop automatically through the actuation of pressure switch (PS-01 @ 12 kg/sq.cm) when the pressure is restored to system pressure. Jockey pump (JP-2) will start automatically through the actuation of pressure switch (PS-02 @ 12 kg/sq.cm) due to fail to start of jockey pump (JP-1).
- b. In the event of hydrant valve opening, the system shall come into operation. Since the water demand shall exceed the pumping rate of jockey pump, it will be unable to restore the system pressure. When the pressure drops by 2 kg/sq.cm (g) (ie. system pressure – 9.30 kg/sq.cm) the motor driven main fire pump shall start automatically through the actuation of a pressure switch ((PS-03 @ 9.30 kg/sq.cm). Engine Driven pump (DHP-1) will start automatically through the actuation of pressure switch (PS-07 @ 6 kg/sq.cm) due to fail to start of Hydrant Pump (HP-1).
- c. If main fire pump fails to start within 15 seconds and the pressure in header drops by 6 kg/sq.cm(g)) (ie. system pressure – 6 kg/sq.cm) the Engine Driven pump (DHP-1) shall start automatically by the actuation of pressure switch (PS-07 @ 6 kg/sq.cm). Engine driven pump (DHP-2) will start automatically through the actuation of pressure switch (PS-08 @ 5.5 kg/sq.cm) due to fail to start of Engine Pump (DHP-1).
- d. The stopping of pumps main fire pump and engine driven shall be manual.

Manual mode

In the manual mode, the motor operated fire water pump & jockey pumps shall be started/stopped using pushbuttons provided on the LPBS/ MCC. For the engine driven pump, start & stop shall be done using pushbuttons on the diesel engine local control panel.

The logic for pump operation for sprinkler system shall be as follows

- a. In case of leakages in the system, the system pressure maintained at 12 kg/sq.cm (g) will drop gradually. When the pressure drops by 0.35 kg/sq.cm(g) (i.e. system pressure- 11.65 kg/sq.cm) , jockey pump (JP-1) shall start automatically through the actuation of pressure switch (PS-01 @ 11.65 kg/sq.cm) . The jockey pump (JP-1) shall stop automatically through the actuation of pressure switch (PS-01 @ 12 kg/sq.cm) when the pressure is restored to system pressure. Jockey pump (JP-2) will start automatically through the actuation of pressure switch (PS-02 @ 12 kg/sq.cm) due to fail to start of jockey pump (JP-1).
- b. In the event of sprinkler burst, the system shall come into operation. Since the water demand shall exceed the pumping rate of jockey pump, it will be unable to restore the system pressure. When the pressure drops by 2 kg/sq.cm (g) (ie. system pressure – 8.30 kg/sq.cm) the motor driven main fire pump(SP) shall start automatically through the actuation of a pressure switch(PS-04 @ 8.30 kg/sq.cm).
- c. If main fire pump fails to start within 15 seconds and the pressure in header drops by 6 kg/sq.cm(g)) (ie. system pressure – 6 kg/sq.cm) the Engine Driven pump (DHP-1) shall start automatically by the actuation of pressure switch(PS-07 @ 6 kg/sq.cm).

Engine driven pump (DHP-2) will start automatically through the actuation of pressure switch (PS-08 @ 5.5 kg/sq.cm) due to fail to start of Engine Pump (DHP-1).

- d. The stopping of pumps main fire pump and engine driven shall be manual.

Manual mode

In the manual mode, the motor operated fire water pump & jockey pumps shall be started/stopped using pushbuttons provided on the LPBS/ MCC. For the engine driven pump, start & stop shall be done using pushbuttons on the diesel engine local control panel.

All these tests mentioned above shall be repeated after one hour interval. The result of all the tests shall be identical again. All consumables including diesel etc required for successful testing, commissioning and handing over of the system are to be borne by the contractor. After the system has satisfactorily withstood the above tests, it can be taken over from the contractor.

Start-up / System Testing:

It will be the responsibility of the tenderer to cause interim/stage inspection by the CFO during execution of the work as and when so called for by the PMC/Employer and shall carry out any rectification / modification as may be suggested by the Fire Authority/Chief Fire Officer (CFO).

Soon after the work is completed, the contractor shall inform the CFO in writing with a copy to the PMC/Employer for getting the complete system including all sub system and instrumentation, control etc. thoroughly inspected and tested for satisfactory performance. After satisfactory completion of tests of the systems by the CFO, the contractor shall be required to submit in built drawings on tracing cloth to the PMC / PROJECT OFFICER which have been so approved.

The contractor shall also be responsible for getting the system and equipment tested and approved by other Statutory Authorities like the Area Fire Officer or the State Fire Services as may be required.

18.2 Samples & catalogues:

Before ordering the material necessary for this work, the contractor shall submit to PMC/Employer for approval, a sample along with the catalogues / technical data sheets. After that the contractor shall arrange inspection and testing at the manufacturer's factory as per approved quality assurance plan or assembly shop for final approval. No material shall be procured prior to the approval of the PMC/Employer

18.3 Shop drawings:

All the shop drawings shall be prepared on computer through licensed AutoCAD, based on Architectural drawings, site measurements and co-ordinated MEP Drawings. Contractor shall furnish, for the approval of the PMC/Employer, FOUR sets of detailed shop drawings of all equipment and materials including layouts for Pump room, Typical drawings showing exact location of supports, flanges, bends, tee connections, reducers, detailed piping drawings showing exact location and type of supports, valves, fittings etc; external insulation details for pipe insulation etc; electrical panels inside/outside views.

These shop drawings shall contain all information required to complete the Project as per specifications and as required by the PMC/Employer. These Drawings shall contain details of construction, size, arrangement, operating clearances, performance characteristics and capacity of all items of equipment, also the details of all related items of work by other contractors. Each shop drawing shall contain tabulation of all measurable items of equipment/materials/works and progressive cumulative totals from other related drawings to arrive at a variation-in-quantity statement at the completion of all shop drawings. Minimum 4 sets of drawings shall be submitted after final approval along with CD.

Each item of equipment/material proposed shall be a standard catalogue product of an established manufacturer strictly from the manufacturers as per Make list. When the PMC/Employer makes any amendments in the above drawings, the contractor shall supply two fresh sets of drawings with the amendments duly incorporated along with check prints, for approval. The contractor shall submit further 4 sets of shop drawings to the Engineer for the exclusive use by the PMC/Employer's site representative and all other agencies. No material or equipment may be installed at the job site until the contractor has in his possession, the approved shop drawing for the particular material/equipment/ installation.

Shop drawings shall be submitted for approval four weeks in advance of planned delivery and installation of any material to allow Engineer ample time for scrutiny. No claims for extension of time shall be entertained because of any delay in the work due to his failure to produce shop drawings at the right time, in accordance with the approved programme.

Approval of shop drawings shall not be considered as a guarantee of measurements or of building dimensions. Where drawings are approved, said approval does not mean that the drawings supersede the contract requirements, nor does it in any way relieve the contractor of the responsibility or requirement to furnish material and perform work as required by the contract.

Where the contractor proposes to use an item of equipment, other than that specified or detailed on the drawings, which requires any redesign of the structure, partitions, foundation, piping, wiring or any other part of the mechanical, electrical or architectural layouts; all such re-design, and all new drawings and detailing required therefore, shall be prepared by the contractor at his own expense and gotten approved by the PMC/Employer. Any delay on such account shall be at the cost of and consequence of the Contractor.

Where the work of the contractor has to be installed in close proximity to, or will interfere with work of other trades, he shall assist in working out space conditions to make a satisfactory adjustment. If so directed by the Engineer In charge's site representative, the contractor shall prepare composite working drawings and sections at a suitable scale, clearly showing how his work is to be installed in relation to the work of other trades. If the Contractor installs his work before coordinating with other trades, or so as to cause any interference with work of other trades, he shall make all the necessary changes without extra cost to the PMC/Employer.

18.4 Test certificate:

The contractor shall submit test certificates for all the material/system installed. These shall be issued by a government recognized inspection office certifying that all equipment, materials, construction and functions are in agreement with the requirements of these specifications, ISI and when ISI is not applicable other approved certifying agencies.

Contractor has to provide Fire NOC (No Objection Certificate) from the local Fire officer (CFO) after the completion of fire Protection system installation. The provisional Fire NOC shall be arranged by the PMC/Employer

18.5 Guarantee:

At the close of the work and before issuance of final certificate of completion by Engineers at site the contractor shall furnish written guarantee indemnifying Engineer against defective materials and workmanship for a period of one year after completion. The contractor shall hold himself fully responsible for reinstallation or replacement, free of cost to Employer for the following:

Any defective work or material supplied by the contractor.

Any material or equipment supplied by PMC/Employer which is damaged or destroyed as a result of defective workmanship by the contractor.

Any material or equipment damaged or destroyed because of defective workmanship by the contractor.

19.0 DATA TO BE FURNISHED BY THE CONTRACTOR AFTER THE AWARD OF CONTRACT AND BEFORE INSTALLATION

- i) Schedule of drawings and documents to be submitted for review, approval, and information with submission dates.
- ii) Quality assurance plan. (QAP).
 - a) Purchase specifications / requisitions for bought out items.
 - b) Measurement and record of settlement during hydro-test / construction.
 - c) Procedure for installation, Operation & Maintenance manual for bought out items.
 - d) As built drawings
- iii) Detailed P & I diagram clearly showing the scope of supply of equipment, piping with line sizes and material specifications, valves, specialties, instrumentation and control and all accessories. This drawing or documents mentioned under following clauses shall include all design data and information furnished. The makes of all major components and controls shall be indicated.
- iv) Dimensioned general arrangement drawing showing all equipment with accessories, mounting details, etc.
- v) Plant installation drawings giving complete details of all the equipment's, including their foundations.
- vi) Fire Protection System layout drawings include insulation giving sizes and lengths of all the pipes and the sizes and locations of all types of valves, and including isometric

drawings for the entire piping including the pipe connections to the various equipment's and insulation details wherever required.

- vii) Line diagram and layout of all electrical control panels giving switchgear ratings and their disposition, cable feeder sizes and their layout,
- viii) Control wiring drawings with all control components and sequence of operations to explain the operation of control circuits.
- ix) Overall space and head room requirement with details of handling during erection, operation and maintenance.
- x) Foundation drawing with static and dynamic loading data, pocket details, foundation outline, etc, for all items.
- xi) Cross-sectional drawings of all items with part list and materials of construction.
- xii) Performance curves and selection charts for fire pumps.
- xiii) Operation and maintenance manual with lubrication schedule.
- xiv) Catalogues furnishing detailed technical data for pumps, hydrant system accessories, valves, Fire Extinguishers etc.
- xv) Final List of Essential Spares.
- xvi) Technical Datasheet, Instrument data sheet and drawings.
- xvii) Internal power and control wiring diagram of the unit mounted electrical panel indicating all interlocks
- xviii) Complete electrical data of the unit with amperages of unit in various conditions, suggested incomer cable etc.
- xix) Motor terminal drawing (s), Motor data sheet, drawing and torque-speed curve
- xx) Clean Agent, lubricating and oil control schematics.
- xxi) Method Statement.
- xxii) Procedure for performance testing.
- xxiii) Test Certificates for the materials.
- xxiv) Manufacturer's printed catalogue for each primer and finish paint material indicating brand name, composition, technical specifications, storage and handling instructions, directions for use, surface preparation requirements and safety information etc.
- xxv) Storing and Handling Practices and Procedures for materials.
- xxvi) Erection, Start-up, Operation and maintenance manual with lubrication schedule. list of routine maintenance checks to be carried out, list of alarms / trip settings, troubleshooting guidelines etc.

19.1 DOCUMENTS TO BE FURNISHED ON COMPLETION OF INSTALLATION

Three sets of the following documents shall be furnished to the department by the contractor on completion of work:

- i) Completion drawings as per schedule.
- ii) 3 sets of manufacturer's technical catalogues of all equipment's and accessories.

- iii) Operation and maintenance manual of all major equipment's, detailing all Adjustments, operation and maintenance procedure, Mandatory & Recommended spares list for each equipment for 5years.

19.2 COMPLETION DOCUMENT/ HANDING OVER:

All commissioning and testing shall be done by the Contractor to the complete satisfaction of the Engineer, and the job handed over to the Employer. Contractor shall also hand over to the Employer all operation & maintenance manuals, as erected drawings & Fire NOC with all items as per the terms of the contract. The following documents shall be submitted by the Contractor in triplicate as part of the completion documents in the proforma prescribed by the PMC/Employer

- (a) Welding procedure specification and Welder qualification report.
- (b) As built drawings incorporating field modifications, if any.
- (c) Contractor shall markup completely and clearly one set of prints of piping drawings of Engineer with approved modifications/field runs carried out at site.
- (d) Radiographic report along with radiographs, All NDT records
- (f) All alignment protocols
- (h) Pipeline hydro test record.
- (j) Quality assurance documentation specific for the project.
- (i) Contractor shall also submit a complete set of approved as built drawings together with performance / rating curves / charts of the equipment, maintenance schedule and test certificates wherever applicable.
- (k) A detailed list of inventory of Fire Protection system to be submitted to the PMC/Employer for his approval as per approved format.

20.0 LIST OF APPROVED MAKES FOR FIRE PROTECTION SYSTEM EQUIPMENTS/ MATERIALS NOTE:

- All materials and products shall conform to the relevant standards and shall be of approved make and design. A list of manufacturers/ Contractor is given separately herein below for guidance. The Engineer shall give the approval of a manufacturer/ Contractor only after review of the sample/ specimen. In case the same is not available in the market or in case of change in trade name, equivalent makes/ re-designated manufacturer then an equivalent approved make shall be used with the approval of Employer/ Engineer. The complete system and installation shall also be in conformity with applicable Codes & Standards and Tender specifications.
- Only "First" class quality materials shall be used.
- Employer reserves the right to choose any of the approved make / Contractor as per this list.
- In case of products not indicated in this list, BIS marked products shall be preferred.
- Specification of manufacturer's item shall be checked against tender item / specifications before selecting any product or brand name. In case of any discrepancy, tender item/ specifications shall prevail, and any such brand of item shall not be used which is not conforming to tender specifications even if it is listed in this list.

- For use of material from a BIS listed/ certified manufacturer, the contractor shall furnish a copy of the BIS certificate to Employer before procuring the material.
- In case non-availability of any item/ material among approved manufacturers/ brands at a particular site/ region, alternate manufacturers/ brands conforming to BIS/ BS etc. shall be used subject to approval by Employer.
- In case of any item/ product neither covered in this list nor having A BIS specification, the contractor shall submit the proposed item/ product along-with technical details/ specifications (as per bid), test certificates etc. And other credentials of the manufacturer for Employers approval.

TECHNICAL SPECIFICATIONS FOR PLUMBING SYSTEM WORKS

CONTENTS

1.0	GENERAL	3
2.0	SANITARY INSTALLATIONS- GENERAL REQUIREMENTS.....	12
3.0	PUMPING SYSTEM.....	18
4.0	LEVEL SENSOR & LEVEL CONTROLLER:.....	35
5.0	WATER DISTRIBUTION SYSTEM.	38
6.0	DRAINAGE.....	86

1.0 GENERAL**1.1 SCOPE OF WORK**

The scope of work to be carried out under this contract is illustrated in Drawings, Specifications and Schedule of Quantities. The Contractor shall carry out and complete the said work under this contract in every respect in conformity with the contract documents and with the direction of and to the satisfaction of the PMC/Employer. The contractor shall furnish all labour, materials and equipment as listed under Schedule of Quantities and specified otherwise, transportation and incidental necessary for supply, installation, testing and commissioning of the complete Plumbing system as described in the Specifications and as shown on the drawings. This also includes any material, equipment, appliances, and incidental work not specifically mentioned herein or noted on the Drawings/Documents as being furnished or installed, but which are necessary and customary to be performed under this contract. The scope of work is as listed below:

- a. Supply, installation, testing, commissioning and handing over of following System / Equipment for the satisfactory operation of the plant.
 - Domestic Water Distribution.
 - Localized Hot water supply.
 - Grey water system (Flushing & Irrigation).
 - Internal Drainage system (Soil, waste and vent).
 - Internal rainwater system (Storm water system).
 - Rainwater harvesting system- collection, distribution & harvesting.
 - Installation of sanitary fixtures and accessories
 - Internal & External Water supply & Distribution
- b. Plumbing pumps, equipment and electrical panel including connection to the various equipment.
- c. Wiring & Earthing from MCC panels to various plumbing, control wiring & interlocking.
- d. All hardware, supports, hangers required for complete installation`
- e. Civil work related to Plumbing Installation
- f. Instruments, meters, gauges, required for the installation and testing.
- g. The scope of work also includes all minor details of construction which are obviously and fairly intended, and which may not have been referred to in these documents but are essential for the entire completion in accordance with standard Engineering practice.

- h. Cutting holes, core cutting, chases & like through all types of walls /floors and finishing for all services crossings, including sealing, frame works, providing sleeve, cover plates, making good structure and finishes to an approved standard. Cutting of holes and core cutting in structural elements shall be carried out with prior approval of structural consultant.
- i. The interface to Building Automation System i.e. and no additional cost shall be paid for providing the interface feasibility.

1.2 SPECIFICATIONS

The detailed specifications given hereinafter are for the items of works described in the schedule of quantities attached herein and shall be guidance for proper execution of work to the required standards. It may also be noted that the specifications are of generalized nature and these shall be read in conjunction with the description of item in schedule of quantities and drawings.

- a. Work under this contract shall be carried out strictly in accordance with specifications attached with tender, TNSOR & CPWD specifications.
- b. The Plumbing System must comply with the standard acceptable authority requirements, NBC, IPC, BS, Local Municipal Authorities, MOEF guidelines, LEED and subject to approval by the Employers representative.
- c. water fixtures for flow rates not exceeding the requirements as follows: (As per LEED Requirements)

Sr. No.	Water Fixture Type	Units	Proposed Flow rates
1	WC	LPF	4/2 Dual Flush
2	Urinals	LPF	< 0.75 liter per flush
3	Faucets	LPM	1.4 LPM (max) @ 60 PSI
4	Showers	LPM	5LPM@ 80 PSI
5	Pre-rinse spray valves	LPM	≤ 5LPM
6	Kitchen Faucets	LPM	1.4 LPM to 2.5LPM (max)@ 60 PSI depending on the type of usage.
7	Health Faucets	LPM	2

1.3 TENDER DRAWINGS, DRAWINGS FOR APPROVAL & COMPLETION DRAWINGS

The drawings provided to the bidder with the tender documents give a general scheme of the system and are not meant to be the working drawings. The contractor shall

furnish the shop drawings to be sent to the PMC/Employer of all the equipment/ layouts after award of the contract and the same shall be approved by the PMC/Employer. No work shall be allowed to be executed without the approved shop drawings.

TENDER DRAWINGS

The drawings appended with the tender documents are intended to show, space allotted for various equipment, tentative cable and pipe routes. The equipment offered shall be suitable for installation in the spaces shown in these drawings.

DRAWINGS FOR APPROVAL ON AWARD OF THE WORK

The contractor shall prepare & required set of following drawings and get them approved from the PMC / Employer before the start of the work. The approval of drawings however does not absolve the contractor not to supply the equipment/ materials as per agreement, if there is any contradiction between the approved drawings and agreement.

- a. Layout drawings of the equipment to be installed in various rooms such as plant room and other equipment.
- b. Drawings including section, showing the details of erection of entire equipment including their foundations, etc.
- c. Plumbing drawings and equipment's showing the layout of entire piping, dia & length of pipes, valves and isometric drawings showing connections to various equipment.
- d. Electrical wiring diagrams for all electrical equipment and controls including the sizes and capacities of the various cables and equipment,
- e. Dimensioned drawings of all electrical and control panels,
- f. Drawings showing the details of all insulations and vapour barrier works,
- g. Drawings showing details of supports for pipes, cable trays etc.
- h. Any other drawings relevant to the work.

1.4 LIST OF APPLICABLE CODES AND STANDARDS:

- a. Plumbing system design shall conform to National Building Code– 2016 Part 9: Plumbing Services Section 1 Water Supply & Section 2 Drainage and Sanitation, and CPHEEO Manuals.
- b. The flow rates of various faucets and cisterns in compliance with LEED Building codes.
- c. All equipment and material being supplied, erected, installed, tested and

commissioned at site shall meet the requirements of Bureau of Indian Standards and other relevant standard and codes.

IS CODE	SUBJECT
IS: 456	Code of practice for Plain & Reinforced concrete.
IS: 458	Specifications for Concrete Pipes.
IS: 554	Dimensions for pipe thread where pressure tight joints are required.
IS: 651	Specifications for Salt glazed stoneware pipes & fittings.
IS: 774	Flushing cistern for water closet and urinals.
IS: 775	Cast iron brackets and supports for wash basin and sink.
IS: 778	Specifications for copper alloy Gate, Globe & Check valves for water works
IS: 779	Water meters (domestic type)
IS: 781	Specifications for cast copper alloy screw down bib taps & stop cocks for water services
IS: 783	Code of practice for laying concrete pipes.
IS: 784	Pre-stressed concrete pipes.
IS: 1172	Code of basic requirements for water supply, drainage and sanitation
IS: 1200 (Pt. 16)	Method of measurements for Laying of water and sewer lines including appurtenant items.
IS: 1200 (Pt. 19)	Method of measurements for Water supply, plumbing and drains.
IS: 1230	Specifications for CI Rain Water pipes
IS: 1239 (Pt I)	Specifications for Mild steel tubes
IS: 1239 (Pt. II)	Specifications for Mild Steel Tubular & other wrought steel pipe fittings
IS: 1536	Specifications for Centrifugally cast iron (spun) pressure pipes for water, gas and sewage
IS: 1537	Specifications for Vertically cast-iron pressure pipes for water, gas and sewage
IS: 1538	Cast iron fittings for pressure pipes for water, gas and sewage
IS: 1701	Combination valve, mixing valves
IS: 1711	Self-closing taps.
IS: 1726	Cast iron manhole covers and Frames.
IS: 1729	Cast /ductile iron drainage pipes & fittings for over ground NP pipeline S/S series.
IS: 1742	Code of practice for building drainage

IS CODE	SUBJECT
IS: 1795	Pillar taps for water supply purposes
IS: 2065	Code of practice for water supply in buildings.
IS: 2082	Specification for Stationary Storage Type Electric Water Heaters.
IS: 2104	Water meter boxes (domestic type)
IS: 2326	Automatic flushing cistern for urinals
IS: 2373	Specification for Water Meter (Bulk type)
IS: 2379	Colour code for identification of pipe lines.
IS: 2401	Code of practice for selection, installation & maintenance of domestic water meters
IS: 2527	Code of practice for fixing rain water gutters and down pipes for roof drainage.
IS: 2548(Pt. I)	Plastic water closet seats and covers.
IS: 2548(Pt. II)	Plastic water closet seats and covers.
IS: 2556(Pt.1)	General requirements
IS: 2556(Pt.2)	Specific requirements of wash down water-closets
IS: 2556(Pt.3)	Specific requirements of squatting pans
IS: 2556(Pt. 4)	Specific requirements of wash basins
IS: 2556(Pt.5)	Specific requirements of laboratory sinks
IS: 2556(Pt.6)	Specific requirements of urinals & partition plate
IS: 2556(Pt.7)	Specific requirements of accessories for sanitary appliances
IS: 2556(Pt.8)	Specific requirements of pedestal close coupled & wash down anti siphon water closets
IS: 2951 (Pt. I to II)	Recommendation for estimate of flow of liquids in closed conduits.
IS: 2951 (Pt. I)	Head loss in straight pipes due to frictional resistance
IS: 2951(Pt. II)	Head loss in valves & fittings.
IS: 3006	Specification for Chemically resistant glazed S.W. pipes and Fitting
IS: 3311	Waste plug & its accessories for sinks & wash basins.
IS: 3389	Urea formaldehyde moulding materials
IS: 3486	Specification for Cast iron spigot and socket drain pipes
IS: 3597	Method of test for concrete pipes.
IS: 3950	Specification for Surface boxes for sluice valve.
IS: 4038	Foot valves for water works purposes.
IS: 4111 (Pt. I to V)	Code of practice for ancillary structures in sewage system.
IS: 4111(Pt. I)	Manholes
IS: 4120	Tubs and baths.

IS CODE	SUBJECT
IS: 4127	Code of practice of laying of glazed stone ware pipes.
IS: 4350	Specification for concrete porous pipes for under drainage.
IS: 4854 (Pt. I to III)	Glossary terms for valves and their parts
IS: 4854(Pt. I)	Screw down stop, check & gate valves & their parts
IS: 4854 (Pt. II)	Plug valves & cocks & their parts
IS: 4854 (Pt. III)	Butterfly valves
IS: 4985	Specifications for un plasticized PVC pipes for potable water supplies
S: 5290	Specifications for Landing valves.
IS: 5312 (Pt. I)	Swing check type reflux (non-return) valves – single door pattern
IS: 5312 (Pt. II)	Swing check type reflux (non-return) valves – multi door pattern
IS: 5329	Code of Practice for sanitary pipe work above ground for building
IS: 5455	Cast iron steps for manholes
IS: 5600	Specifications for Sewage and drainage pumps
IS: 5961	Specifications for CI grating for drainage purposes
IS: 6279	Equipment for grit removal
IS: 6411	Specifications for gel coated glass fibre reinforced polyester resin bath tubs
IS: 6418	Cast Iron & malleable flanges for general engineering purpose
IS: 6587	Specifications for Spun hemp yarn
IS: 7181	Horizontally Cast Iron Double Flanged pipe for water, gas & sewage.
IS: 7231	Specifications for Plastic Flushing Cisterns for water closet & urinals
IS: 7558	Code of Practice for domestic hot water installations
IS: 7634 (Pt. I to III)	Code of Practice for Plastic pipe work for potable water supplies
IS: 7634 (Pt. I)	Choice of materials & general recommendations
IS: 7634 (Pt. II)	Laying & jointing polyethylene (PE) pipes
IS: 7634 (Pt. III)	Laying & jointing un plasticized PVC pipes
IS: 7740	Code of Practice for road gullies
IS: 7834 (Pt. I to VIII)	Injection moulded PVC socket fittings with solvent cement joints for water supplies
IS: 7834(Pt. I)	General requirements
IS: 7834 (Pt. II)	Specific requirements for 45 elbows
IS: 7834 (Pt. III)	Specific requirements for 90 elbows
IS: 7834 (Pt. IV)	Specific requirements for 90 tees

IS CODE	SUBJECT
IS: 7834(Pt. V)	Specific requirements for 45 tees
IS: 7834 (Pt. VI)	Specific requirements for sockets
IS: 7834(Pt. VII)	Specific requirements for unions
IS: 7834 (Pt. VIII)	Specific requirements for caps
IS: 8835	Guideline for planning and design of surface drains.
IS: 8931	Specifications for copper alloys Fancy single taps, combination tap assembly & stop valves for water services
IS: 9140	Method of sampling of vitreous & fire clay sanitary appliances
IS: 9338	Specifications for Cast Iron screw down stop valves and stop & check valves for water works purposes
IS: 9739	Specifications for Pressure reducing valves for Domestic water supply system.
IS: 9758	Specification for Flush valves and Fittings for water closets and urinals
IS: 9763	Specifications for Plastic Bib taps, pillar taps, angle valves and stop valves for hot & cold-water service.
IS: 10500	Specification of Drinking water
IS: 10592	Specification for Industrial Emergency Showers, Eye and Face Fountains and Combination units
IS: 11606	Method for sampling of cast iron pipes and fittings.
IS: 12183 (Pt. I)	Code of practice for Plumbing in multi-storied buildings (for water supply)
IS: 12231	UPVC pipes for section & delivery lines of agricultural pumps– Specification.
IS: 12235	Method of test for UPVC pipe for potable water supply
IS: 12288	Code of practice for use and laying of Ductile Iron pipes.
IS: 12469	Specifications for pumps
IS: 12592	Precast concrete frame & cover (SFRC frame & cover)
IS: 12820	Dimensional Req. of Rubber Gaskets for Mechanical Joints & push in joints for use with Cast Iron Pipes & fittings for carrying water, Gas & sewage.
IS: 13095	Butterfly valves for general purposes
IS: 13114	Specification for forged brass gate, globe & check valves for water works purposes

IS CODE	SUBJECT
IS: 13382	Cast Iron specials for mechanical & push-on flexible joints for pressure pipelines for water, gas & sewage
IS: 13592	Specifications for PVC soil, waste & rain water (SWR) including ventilation pipes
IS: 13983	Specifications for stainless-steel kitchen sinks & drain boards for domestic purpose
IS: 14735	UPVC injection moulded fittings for UPVC – SWR pipes – Specifications.
IS: 14845	Resilient seated cast iron air relief valves for water works purposes – Specifications
IS:15328	UPVC non-pressure pipes for use in underground drainage and sewerage system – Specifications.
IS: 16098 (Part 1)	Specifications for Structured Wall PVC Pipes for Drain & Sewer
IS: 16098 (Part 2)	Specifications for Structured Wall Pipes & Fittings for Non-smooth surface

1.5 DATA TO BE FURNISHED BY THE CONTRACTOR AFTER THE AWARD OF CONTRACT AND BEFORE INSTALLATION

- a. Schedule of drawings and documents to be submitted for review, approval and information with submission dates.
- b. Quality Assurance Plan (QAP).
- c. Detailed P & I diagram showing clearly the scope of supply of equipment, piping with line sizes and material specifications, valves, specialties, instrumentation and control and all accessories. This drawing or documents mentioned under following clauses shall include all design data and information furnished in data sheets. The makes of all major components and controls shall be indicated.
- d. Dimensioned general arrangement drawing showing all equipment with accessories, mounting details, etc.
- e. Overall space and head room requirement with details of handling during erection, operation and maintenance.
- f. Foundation drawing with static and dynamic loading data, pocket details, foundation outline, etc, for all items.
- g. Cross-sectional drawings of all items with part list and materials of construction.
- h. Performance curves and selection charts for Pumps
- i. Operation and maintenance manual with lubrication schedule.

- j. Catalogues furnishing detailed technical data for Pumps, control panel, valves.
- k. Final List of Essential Spares.
- l. Technical Datasheet, Instrument data sheet and drawings.
- m. Internal power and control wiring diagram of the unit mounted electrical panel indicating all interlocks
- n. Complete electrical data of the unit with amperages of unit in various conditions, suggested incomer cable etc.
- o. Motor terminal drawing (s), Motor data sheet, drawing and torque-speed curve
- p. Method Statement.
- q. Procedure for performance testing.
- r. List of insulation materials with specifications and properties.
- s. List of insulation adhesives, vapour barriers and finishing materials with specifications.
- t. Sample Materials such as sanitary wares and CP fittings for approval.
- u. Test Certificates for the materials.
- v. Manufacturer's printed catalogue for each primer and finish paint material indicating brand name, composition, technical specifications, storage and handling instructions, directions for use, surface preparation requirements and safety information etc.
- w. Storing and Handling Practices and Procedures for materials.
- x. Erection, Start-up, Operation and maintenance manual with lubrication schedule. list of routine maintenance checks to be carried out, list of alarms / trip settings, troubleshooting guidelines etc.

1.6 HANDING OVER DOCUMENTS

- a. On completion of work, contractor shall submit one complete set of as built drawings in editable soft copy and two hard prints of 'as built' drawings to the Engineer. These drawings shall have the following information:
- b. Ground and invert levels of all drainage pipes together with location of all manhole and connections up to outfall.
- c. Location of all mechanical equipment with layout and piping connections & location of electrical panel for the same.
- d. All technical data sheets for the mechanical equipment's, such as pumps, solar hot water generators, air-to-water heat pumps, sump pumps, etc.
- e. All technical data sheets for the electrical actuator operated butterfly valves, electronic flow meters, etc.

- f. Contractor shall provide four sets of catalogues, performance data and list of spare parts together with the name and address of the manufacturer for all electrical and mechanical equipment provided by him.
- g. All 'warranty cards' given by the manufacturers shall be handed over to the Engineer.
- h. Contractor shall provide Operation and Maintenance manual of all major Electro-mechanical equipment.
- i. All test certificates of materials & testing at manufacturer works shall be submitted in one set of hard copy.
- j. All site performance test certificates approved by Engineer shall be submitted in one set of hard copy.

1.7 TOOLS AND TACKLE

All tools, tackle, scaffolding and staging required for erection and assembly of the equipment and installation covered by the contract shall be obtained by the bidder himself. All other materials such as foundation bolts, nuts, steel inserts etc. required for the installation of the plant shall also be supplied and included in the contract.

1.8 STATUTORY INSPECTIONS

The Bidder shall be fully responsible for meeting all the statutory obligations & local inspectorates wherever applicable to the works carried out by them. The bidder should prepare all working drawings and obtain approval of competent authorities and also have the equipment and installation inspected and got approved. All official fees will be paid by TIDEL directly against demand in writing from the appropriate authority and all other expenses for submission and approval of the various and relevant statutory / bodies shall be embodied in the tender prices.

2.0 SANITARY INSTALLATIONS- GENERAL REQUIREMENTS

2.1 SCOPE

The scope of this section consists of but is not necessarily limited to installation, testing and commissioning of following items:

- a. Sanitary appliances and fixtures for toilets.
- b. Chromium plated brass/other fittings
- c. Sinks
- d. Accessories e.g. towel rods, toilet paper holders, soap dish, liquid soap

dispensers, towel rails, coat hooks etc.

e. Hand driers, drinking water fountains etc.

Whether specifically mentioned or not the Contractor shall provide for all appliances and fixtures all fixing devices, nuts, bolts, screws, hangers, supports, accessories as required for complete installation.

NOTE: FOR SUPPLY SCOPE SPECIFICATION SANITARY FIXTURES MAKE, MODEL NUMBER SUPPLY RATES REFER ARCHITECTURAL SPECIFICATIONS

2.2 GENERAL REQUIREMENTS

Sanitary appliances and fixtures for toilets, chromium plated brass fittings, stainless steel sinks, bathroom accessories like towel rods, toilet paper holders, soap dish, liquid soap dispensers, towel rails coat hooks etc and mirrors, hand driers, drinking water fountains etc as listed in the relevant items in the Schedule of Quantities shall be supplied free of cost by the PMC/Employer's Site Representative. The rates shall be inclusive of accessories (in such case) required for installation. All sanitary fixtures and fittings shall received from the PMC/Employer's Site Representative and thereafter be stored under covered roof and handled carefully to prevent any damage by the Contractor.

All appliances, fixtures and fittings shall be provided with all such accessories as are required to complete the item in working condition whether specifically mentioned or not in the Schedule of Quantities, specifications, drawings. Accessories shall include proper fixing arrangements, brackets, nuts, bolts, washers, screws and required connection pieces.

The sanitary fixtures and fittings shall be installed at the correct assigned position as shown on the drawings and as directed by the Architect / PMC/Employer's Site Representative and shall fully meet with the aesthetic and symmetrical requirements as demanded by the Architect / Interior Designer

All fixtures and accessories shall be fixed in accordance with a set pattern matching the tiles or interior finish as per Architect requirements. Wherever necessary, the fittings shall be cantered to dimensions and pattern as called for.

Fixing screws shall be half round head chromium plated (CP) brass screws, with CP brass washers unless otherwise specified.

Fixtures shall be installed by skilled workman with appropriate tools according to the best trade practice.

All appliances, fittings and fixtures shall be fixed in a neat workmanlike manner true to level and to heights shown on the drawings and in accordance with the manufacturer's recommendations. Care shall be taken to fix all inlet and outlet pipes at correct positions. Faulty locations shall be made good and any damage to the finished floor, tiling, plaster, paint, insulation or terrace shall be made good by the Contractor at his own cost. Fixtures shall be mounted rigid, plumb and true to alignment.

All materials shall be rust proofed ; materials in direct or indirect contact shall be compatible to prevent electrolytic or chemical (bimetallic) corrosion.

Wall flanges shall be provided on all walls, floors, columns etc. wherever supply and disposal pipes pierce through them. These wall caps shall be or chromium plated brass fittings and the receiving pipes and shall be large enough to cover the punctures properly.

Sanitary appliances, subject to the type of appliance and specific requirements, shall be fixed in accordance with the relevant standards and the following :

- a. Contractor shall, during the entire period of installation and afterwards protect the appliances by providing suitable cover or any other protection so as to absolutely prevent any damage to the appliances until handing over (The original protective wrapping shall be left in position for as long as possible)
- b. The appliances shall be placed in correct position or marked out in order that pipe work can be fixed or partially fixed first.
- c. The appliance shall be fixed in a manner such that it will facilitate subsequent removal if necessary.
- d. The appliance shall be securely fixed. Manufacturer's brackets and fixing methods shall be used wherever possible. Compatible rust-proofed fixings shall be used. Fixing shall be done in manners that minimize noise transmission.
- e. Appliances shall not be bedded (e.g. WC pans, pedestal units) in thick strong mortar that could crack the unit (e.g. ceramic unit)
- f. Pipe connections shall be made with demountable unions. Pipe work shall not be fixed in a manner that it supports or partially supports and appliance.

- g. Appliances shall be fixed true to level firmly fixed to anchor or supports provided by the manufacturer and additional anchors or supports where necessary.

Sizes of sanitary fixtures given in the Specifications or in the Schedule of Quantities are for identification with reference to the catalogues of make considered. Dimensions of similar models of other makes may vary within + 10% and the same shall be provided and no claim for extra payment shall be entertained NOR shall any payment be deducted on this account.

The contractor shall fix all plumbing fittings such as water faucets, shower fittings, mixing valves etc. in accordance with manufacturer's instructions and connect to piping system. The contractor shall supply all fixing materials such as screws, rawl plugs, unions, collars, compression fittings etc., as required.

Joints / gaps between all sanitary appliances / fixtures and the floor / walls shall be caulked with an approved mildew resistant sealant, having antifungal properties, of colour and shade to match that of the appliances / fixture and the floor / wall to the extent possible.

2.3 MOCKUP & TRAIL ASSEMBLY

The installation of the Sanitary fixtures and fittings shall be as per the shop drawings approved by the Architect/Consultant.

The contractor shall have to assemble at least one set of each type of sanitary fixtures and fittings in order to determine precisely the required supply and disposal connections. Relevant instructions from manufacturers shall be followed as applicable. This trial assembly shall be developed to determine the location of puncture holes, holding devices etc. which will be required for final installation of all sanitary fixtures and fittings. The above assembly shall be subject to final approval by the Architect / Interior Designer.

The fixtures in the trial assembly can be re-used for final installation without any additional payments for fixing or dismantling of the fixtures.

2.4 SUPPORTING & FIXING DEVICES

The contractor shall provide all the necessary supporting and fixing devices to install the sanitary fixtures and fittings securely in position. The fixing devices shall be rigidly anchored into the building structure. The devices shall be rust resistant and shall be so fixed that they do not present an unsightly appearance in the final assembly SS:304 Nut Bolts & screw. Where the location demands, the Architect may instruct the contractor to provide chromium plated or other similarly finished fixing devices. In such circumstances the contractor shall arrange to supply the fixing devices and shall be installed complete with appropriate vibration isolating pads, washers and gaskets.

2.5 FINAL INSTALLATION

The contractor shall install all sanitary fixtures and fittings in their final position in accordance with approved trial assemblies and as shown on drawings. The installation shall be complete with all supply and waste connections. The connection between building and piping system and the sanitary fixtures shall be through proper unions and flanges to facilitate removal/replacement of sanitary fixtures without disturbing the built in piping system. All unions and flanges shall match in appearance with other exposed fittings.

Fixtures shall be mounted rigid, plumb and to alignment. The outlets of water closet pans and similar appliances shall be examined to ensure that outlet ends are butting on the receiving pipes before making the joints. It shall be ensured that the receiving pipes are clear of obstruction. When fixtures are being mounted, attention shall be paid to the possibility of movement and settlement by other causes. Overflows shall be made to ensure that necessary anchoring devices have been provided for supporting water closets, wash basins, sinks and other appliances.

2.6 PROTECTION AGAINST DAMAGE

Contractor shall, during the entire period of installation and afterwards protect the appliances by providing suitable cover or any other protection to absolutely prevent any damage to the appliances until handing over. (The original protective wrapping shall be left in position for as long as possible).

The contractor shall take every precaution to protect all sanitary fixtures against damage, misuse, cracking, staining, breakage and pilferage by providing proper wrapping and locking arrangement till the completion of the installation. At the time of handing over, the contractor shall clean, disinfect and polish all the fixtures and fittings. Any fixtures and fittings found damaged, cracked chipped stained or scratched shall be

removed and new fixtures and fittings free from defects shall be installed at his own cost to complete the work.

2.7 TEST AND ACCEPTANCE

All appliances, fixtures and fittings shall be tested before and after installation. Water seals of all appliances shall be tested. The contractor shall block the ends of waste and ventilation pipes and shall conduct an air test/water test.

- a. The sanitary fixtures form the final terminal units of the water supply and drainage system and shall meet the performance needs as a terminal unit. Each fixture shall be inspected for scratches or chippings and alignment before acceptance.
- b. All Appliances, fixtures and fittings shall be provided with all such accessories as are required to complete the item in working condition whether specifically mentioned or not in the Schedule of Quantities, specifications, and drawings. Accessories shall include proper fixing arrangement, brackets, nuts, bolts, screws and required connection pieces.
- c. Fixing screws shall be half round head chromium plated brass screws with C.P. washers where necessary.
- d. All materials shall be rust proof; materials in direct/ indirect contact shall be compatible to prevent electrolytic or chemical (bimetallic) corrosion.
- e. Sanitary appliances, subject to the type of appliance and specific requirements, shall be fixed in accordance with the relevant standards/ best practices by skilled labours.
- f. All Appliances, fittings and fixtures shall be fixed in a neat workmanlike manner true to level and heights shown on the drawings and in accordance with the manufacturer's recommendations. Care shall be taken to fix all inlet and outlet pipes at correct positions. Faulty locations shall be made good and any damage to the finished floor, Filing Plaster, Paint, insulation or terrace shall be made good by the Contractor at his own cost.
- g. CP Wall flanges shall be provided on walls, floors, etc. wherever supply/discharge pipes pierce through them. These flanges/fittings shall be large enough to cover punctures properly.
- h. The appliance shall be fixed in a manner such that it will facilitate subsequent removal if necessary.
- i. All appliances shall be securely fixed. Manufacturers' brackets and fixing methods shall be used wherever possible. Compatible rust- proofed fixings shall be used.

Fixing shall be done in a manner that minimizes noise transmission.

- j. Pipe connections shall be made with demountable unions. Pipe work shall not be fixed in a manner that it supports or partially supports an appliance.
- k. Appliances shall be fixed so that water falls to the outlet.
- l. Appliances shall be fixed true to level firmly fixed to anchor or supports provided by the manufacturer and additional anchors or supports where necessary.
- m. Fixtures shall be generally installed at following heights or as directed by PMC/Employer.
 - a) Water Closet : 390 mm to top of bowl rim
 - b) Bidet : 390 mm to top of bowl rim
 - c) Urinal : 650 mm to top of bowl rim
 - d) Wash basin/ Sink : 750-800 mm to top of bowl rim
- n. Joints/ gaps between all sanitary appliances/fixtures & the floor/wall shall be caulked with an approved quality sealant, having antifungal properties, colour & shade to match that of the appliances/fixture & floor/wall to the extent possible.
- o. Care shall be taken in fixing all approved CP fixtures & accessories so as not to leave any tool marks or damage on the finish. All fixtures shall be tightened with fixed spanner.
- p. All fixtures shall be thoroughly tested after connecting the drainage & water supply system. All fixtures shall be thoroughly finished & any leakage in piping/valves/ waste fittings shall be corrected to the complete satisfaction of Engineer.
- q. Upon completion of work, all labels, stickers, plaster, etc. shall be removed from the fixtures & all fixtures shall be cleaned with soap & water to present a neat & clean toilet.

3.0 PUMPING SYSTEM.

3.1 SCOPE

The scope of work shall cover Design, engineering, supply of equipment, manufacturing, interconnecting piping, electrical, instrumentation, inspection and testing, painting, packing and forwarding, supply to site, unloading and storage at site, installation and commissioning, performance guarantee and handover of Pumps meeting the intents of these specifications. The plant shall generally comprise, but not limited to, the following:

- Water transfer pumps
- Sump pit pumps
- Hydropneumatic Booster pumps

- All piping and valves from pumps to vessels to tanks

3.2 TRANSFER PUMPS:

Transfer pumping units shall be provided for supply of domestic water/flushing water/HVAC makeup water supply From UGT to OHT. The units shall be selected so as to provide at minimum of 1.5 bar pressure at the OHT and Supply of irrigation water/flushing water/HVAC makeup water supply From STP to UGT. The units shall be selected so as to provide at minimum of 1.5 bar pressure at the UGT.

3.2.1 SCOPE

This section of the contract involves the design, supply, installation, testing and commissioning of the complete transfer pumping system complete with all controls, control panel (IP 55 enclosure) and electrical work for water supply from STP to UGT & UGT to OHT. Includes testing and commissioning of water supply system. All installation work shall comply with the latest rules and regulations. The work embraced by this specification covers the design, submission to authorities, supply and delivery on site, installation, testing, commissioning and maintenance of the Transfer pumping system, installation of the building in accordance with this specification and associated drawings.

The scope of work shall include the following (list is indicative and not exhaustive): -

- Vertical inline multistage pump as described in earlier section.
- IP 55 Control panel for pump control complete with constant speed drives as shown in drawings, circuit breakers, fuses, high pressure switch, etc. complete with all interconnections to pumps and electrical supply panels.
- Pump control units complete with pre-programmed micro-processor chip.
- Pump monitoring units to monitor operation of pumps.
- Pump dry run protection.
- High pressure protection along with pressure relief valve at discharge header
- Pumps cyclic operation system (lead /Lag)
- Each Transfer Pumping unit system shall be supplied as complete set mounting on common base including suction and discharge common manifolds, non-return valves, isolating valves, flexible couplings, pressure gages, control panel, High pressure switches etc,

- Each unit shall be provided with electronic microprocessors for unit control and all necessary electrical work for the unit.

3.2.2 CODES & STANDARDS

The design, material, construction, manufacture, inspection, testing and performance of vertical multistage pumps shall comply with all currently applicable statutes, regulations and safety codes in the locality where the Equipment will be installed. The Equipment supplied complies with the latest applicable Standards. The work in this section is subject to the requirements of applicable portions of the following standards:

EN 809	Pumps and pump units for liquids – Common safety requirements
ISO 9906	Roto-dynamic pumps - Hydraulic performance acceptance tests- Grade1, 2 & 3
ISO 10816	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts
EN 1092-2	Flanges standard used for cast iron pump flanges dimensions.

3.2.3 GENERAL

- a. The pump shall be vertical multistage, centrifugal directly coupled to motor, used for transfer of potable /flushing water from underground tank to overhead tank of the each building or other application. The pump shall be capable of developing the required head at the rated capacity at a power supply frequency of 50 Hz. The pump motors shall be of Class “F” insulation and IP55 rating and shall be provided with built-in thermistors for protection against overheating.
- b. Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the specifications without surging, cavitations or excessive vibration to the limits specified. The pump shall meet maximum allowable shut off head. The pumps shall not overload the motors at any point on the maximum pump speed performance characteristic curve and the pump operating range within the limits of stable pump operation. The total head capacity curve shall be continuously rising towards the shut off as flow decreases throughout the entire curve from run out to shut off head with the highest at shut off.
- c. Its total head capacity curve shall be continuously rising towards shut off with the

highest at shut off, and its capacity shall meet to handling sludge volume.

- d. Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.
- e. Pumps shall run smooth without undue noise and vibration, cavitations, oil or water leaks over the range of operation. To ensure vibration free operation, all rotating components of pump shall be statically and dynamically balanced to BS 6861/ as per zones A & B of ISO 10816 -1 .
- f. The pump set shall be suitable for starting with discharge valve open and/or closed.
- g. The pump set shall be capable of withstanding the accidental rotation in reverse direction.
- h. Pumps shall be so selected that the design duty point is within 5% of the maximum efficiency point. Pump minimum efficiency shall not be less than 70% at duty point.
- i. The pump casing shall have ample space to take an impeller one size larger than that capable of performing the design duty.
- j. The pump shall have a speed of not more than 1500 rpm.
- k. The pump shall be lubricated in strict accordance with the manufacturer`s instructions and shall be factory aligned prior to shipment.
- l. All pumps shall have mechanical seal.

3.2.4 MOTOR

All motors shall be suitable for Constant speed as applicable.

PERFORMANCE AND CHARACTERISTICS

- a. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under either of the following supply conditions: -
- b. Variation of supply voltage from rated motor voltage $\pm 10\%$
- c. Variation in supply frequency from rated frequency $\pm 5\%$
- d. Combined voltage and frequency variation $\pm 10\%$

- e. Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperature, when the supply voltage is in the range of 85% of the rated voltage. Starting current of motor shall not exceed 200% of rated full load current.
- f. Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.
- g. Motors shall be capable of developing the rated full load torque even when the supply voltage drops to 70% of the rated voltage. Such operation is envisaged for a period of 1 second. The pull out torque of the motor, to meet this requirement, shall be at least 205% of full load torque.
- h. The locked rotor current of the motors shall not exceed (inclusive of 20% tolerance) 600% of full load current for motors.
- i. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the specified supply condition.
- j. The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than the starting time at 80% voltage by at least two seconds or 15% of the accelerating time whichever is greater.
- k. Motors when started with the drive imposing its full starting torque under the supply voltage variations specified shall be capable of withstanding at least two successive starts from cold condition and one start from hot condition without injurious heating of windings. The motors shall also be suitable for four equally spread starts per hour under the above referred supply conditions.

3.2.5 INSULATION

Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with Class F insulation with temperature rise limited to that of Class B insulation.

3.2.6 ACCESSORIES

Motors shall have drain plugs so located that they will drain water, resulting from condensation or other cases from all pockets in the motor casing. The earthing pads shall be of non-corrodible metal welded or brazed at two locations on opposite sides.

3.2.7 HYDROSTATIC TESTS

- a. Hydro test pressure on casing shall be 1.5 times maximum discharge head or twice differential head whichever is higher. (Maximum discharge head = shut-off head + maximum suction head). Unless otherwise stated in data sheet A, the hydrostatic tests on the casing shall be conducted for a minimum duration of 30 minutes.
- b. The pumps shall be tested as per IS 11346:2004, at rated speed at MANUFACTURER's works to measure capacity, total head, efficiency and power. These tests shall form the basis for acceptance of pumps except for vibration and noise. The pumps shall be tested over the range covering from shut-off head to the maximum flow. The duration of the test shall be minimum one (1) hour. Minimum five (5) readings approximately equidistant shall be taken for plotting the performance curves.
- c. After installation, the pumps shall be subjected to performance testing at site also. If the site performance is found not to meet the requirements regarding vibration and noise as specified, the equipment shall be rectified or replaced by the VENDOR, at no extra cost to the PURCHASER.

3.2.8 PERFORMANCE TESTS

Motor shall be subjected to all the routine tests as per applicable standard in the presence of the PURCHASER'S representative. Copies of test certificates of type and routine tests shall be furnished as specified in the distribution schedule, for the PURCHASER'S approval. The VENDOR shall ensure to use calibrated test equipment/instruments having valid calibration test certificates from standard laboratories traceable to national/international standards.

If type tests have not been carried out on similar Motors, or if the type test reports submitted are not found in order, then VENDOR shall carry out these tests without any extra cost to the Purchaser.

3.2.9 INSPECTION

The contractor shall provide facilities for inspection of the components of the pump during all stages of manufacture to check conformity to specification. The following inspection shall be invariably be witnessed by the PMC/Employer.

Vertical inline pumps - Casing Hydro test, Performance Testing

3.2.10 NAME PLATE

Each pump shall be provided with a name plate indicating the following details:

1. Pump type designation
2. Pump Model
3. Rated flow
4. Rated head
5. Rated speed
6. Power P2
7. Pressure rating/max temperature
8. Serial Number
9. MEI (Minimum Efficiency Index)
10. Voltage
11. Frequency

3.3 HYDROPNEUMATIC SYSTEM**3.3.1 SCOPE**

- a. Supply, Installation, Testing and Commissioning of Compact Self-Contained Skid Mounted Hydro-pneumatic System including a pre-engineered, factory fabricated, assembled & tested, fully integrated, highly efficient pump with IE3 motors, skid mounted, complete ready-to-connect packaged variable speed water pressure booster station along with pilot pump (capacity equivalent to 20% of total system capacity).
- b. All installations such as electrical wiring from Electrical Panel to Pump panel, civil foundations, etc is included in this scope.
- c. The item includes the Pumps (Vertical inline centrifugal type), Pressure vessels, pressure gauges, pressure Switches / transmitter / transducer on Suction / delivery manifold, pump suction & delivery piping, manifolds & valves, flexible bellows, Fixed speed/variable frequency drive, control panels, Microprocessor based operation) and all accessories including installation, testing & commissioning.

3.3.2 PUMP-MOTOR SET**DESIGN & CONSTRUCTION FEATURES**

- a. Inline vertical multistage type centrifugal pump shall be provided.
- b. Variable frequency drive shall be provided with all the pumps, with potential free contacts to monitor on/off status & trip status.
- c. The pump motor set and shall be suitable for 1Ph or 3 Ph., 230 or 415 V, 50 Hz.

AC power supply and having 1450/ 2900 RPM speed.

- d. The packaged variable speed water pressure booster station shall be complete with vertical multi stage centrifugal pumps connected in parallel, with high efficiency IE 3 motors, an air-cooled external variable frequency drive, intelligent multi-pump controller, the controller shall be mounted in a control cabinet with an IP 55 enclosure of suitable rating having potential free contacts to monitor On/Off & Trip status with necessary sensors/switches; hot Dipped Galvanized suction and delivery manifolds; isolation ball valves on suction and discharge of each pump; non return valve on discharge side of each pump; hot dip galvanized common base frame; and diaphragm pressure vessel.
- e. A dedicated intelligent multi-pump logic controller for control and monitoring of pumps shall be from the pump manufacturer with easy interface graphical 320 X 240 Pixels colour display unit with key function controller should able to monitor multiple operating parameters (flow, inlet pressure, outlet pressure, instant flow estimation, cumulative flow and speed etc) to calculate best operating algorithm to pump sequence optimally.
- f. Mentioned features should be available, automatic pump alternations for run time equalization, programmable number of starts/stops per hour to prevent pump hunting, Stand by pump selection, pump test run, friction loss compensation, redundant primary sensor for pressure monitoring, soft pressure built-up, log graph display for key parameters, clock program for multiple set point for scheduled system operation.
- g. Multi pump controller should have on-board Ethernet facility for BMS.
- h. Complete (Skid mounted) electrical control panel comprising of all accessories such as PLCs, pressure switches, pressure transducers, control wiring and any other necessary imports etc.
- i. All installations such as electrical wiring from Electrical Panel to Pump panel, civil foundations, etc is included in this scope.
- j. The pump shall be installed with isolation gate/ butterfly valve, non-return valve, etc. The detailed specification for pump & motor is as below:
- k. The design and manufacture of the pump shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.
- l. The pump shall can develop required total head at rated capacity. Impeller shall be closed type and shall be dynamically balanced. The pump shall have non-overloading characteristics.

- m. The casing shall be of rigid construction and shall have side suction and side delivery in case of vertical multistage pump and side suction and central delivery in case of horizontal centrifugal pump.
- n. The pump shall have very small length suction and delivery pipe connections which will result in minimum friction loss.
- o. Impeller shall be of one piece and shall be of SS.
- p. The shaft shall be of S.S. and its surface shall be properly finished.
- q. Shaft sleeves shall be provided to protect shaft from any damage.
- r. Bearing shall be ball or roller type.
- s. Mechanical seal shall be provided to avoid any leakage.
- t. Pump shall be mounted on a concrete foundation, projecting at least 15 CM above finished floor level. The pumps base shall be set on an anti-vibration pad.
- u. All the parts of the pumps that are in contact with water e.g. shaft, impeller etc. shall be hot dip galvanized or of stainless steel construction.
- v. Pumps shall be so selected that the design duty point is within 5% of the maximum efficiency point. Shut off head shall be 120% of duty point head.
- w. All pumps and motors shall be of minimum vibration and noise level during operation. Vibration isolators shall be provided for all pump sets.
- x. Facilities shall be provided to prevent starting of pumps when the water tank is at low water level.
- y. An indicator for this low water level alarm shall be provided.
- z. Facilities to select which pump to be duty pump and standby pump shall be provided and be interchangeable.
- aa. Leakage from pump gland shall be drained to the nearest floor waste.
- bb. Pump shall be driven by directly coupled squirrel cage induction motor having TEFC enclosure, IP 67 protection & shall be of Class F insulation.
- cc. Pump motors above 7.5 kW shall be equipped with a spacer coupling which allows changing of shaft seals without removing the motor.
- dd. All poly-phase motors of (capacity >0.375 kW and operating hours >1500 hours/year) shall follow minimum efficiency level as per IS 12615 for energy efficient motors.
- ee. Pressure vessel of non-corrosive FRP composite construction lined with NSF and/or FDA listed material, like high density polyethylene with fully replaceable polyurethane. Air cell burst pressure of minimum of 5 times the vessel operating pressure and cycle tested for 80,000 cycles with charging connections to discharge pipe line with necessary flanges, gaskets, isolating valves, nuts/bolts etc complete.

3.3.3 INSPECTION & TESTING

- a. The pump shall be offered for visual inspection before dispatch.
- b. if the Engineer require, he may ask for a Factory Acceptance Test, and for this the contractor is bound to make the adequate arrangements for the factory visit at no extra charge.
- c. Material test certificates for the various pump components shall be furnished for Engineer's approval

3.3.4 SYSTEM DESCRIPTION

- a. The system operation will be such that the initial small water demand shall be met by the charged diaphragm pressure vessel. When the water demand continues, the system pressure will dip to a pre-set pump cut-in point when the lead pump starts to operate at reduced speed through the variable speed drive. However, if the system pressure be still below the pre-set value, the controller continuously increases pump speed to meet the system demand. When the lead pump is not able to meet the system pressure at full speed, the second pump also starts to operate.
- b. At peak demand all the pumps operate, similarly, if there is a drop-in water demand the duty pump speed starts to reduce, then standby pumps cuts-off, followed by stopping of the duty pump.
- c. The closed diaphragm pressure vessel shall be of polyethylene material with a pressure gauge and isolating valve. The interior shall be of non-toxic lining suitable for use with potable water. The vessel shall be manufactured to conform to ASME pressure vessel code/standards.
- d. The system shall be under the control of a microprocessor-based control panel.
- e. A pressure transmitter shall detect the pressure at the delivery manifold and feedback to the microprocessor control panel via control circuit.
- f. The system shall incorporate a frequency converter or frequency converter motors on the pumps and the pressure transmitter shall register the actual pressure on the discharge side.
- g. The variable frequency drive pumping system shall maintain a constant pressure regardless of the system demand. If there is a drop-in pressure outside the pre-set point, the Variable Frequency Drive (VFD) pump shall start to run until the pressure increases to the pre-set limit, or it will continue to increase the pump speeds to the upper limit of the frequency. If the water system demand still cannot be met, the second pump shall be called in to run, the VFD will then alter the pump speed to meet the pre-set pressure point. If the set point is still unable to be met, the third pump is then activated to run (in case of 3 pumps units).

- h. This shall be achieved by continuously varying the motor speed of the duty pump according to the demand up to a maximum designed capacity.
- i. Under decreasing hydraulic demand, the reverse sequence to the above description shall apply. Alternatively, pumping system shall be with fixed speed drive motor. By getting the signal from microprocessor-based control panel through pressure transmitter, pumps will operate in sequence & vice a versa.
- j. The frequency converter shall be linked to the motor of the duty pump for continuous speed adjustment and ultimately the water delivery shall be maintained at constant pressure at the pre-set value.

3.3.5 CONTROL PANEL

- a. The motor control panel shall be equipped with all the necessary electrical components including a microprocessor control unit and a frequency drive. The control panel and the microprocessor shall cover the followings functions.
- b. Flexibility and simplicity in allowing the necessary re-adjustment of the pumping system pre-set delivery pressure to operate the pumps within the specified maximum and minimum delivery ranges.
- c. Automatic changeover of the pumps to be controlled by the microprocessor which dictates the duty and standby pumps.
- d. When the system has not been operated for more than 24 hours, it shall automatically start the pumps for a few seconds / day to ensure the pumps readiness always. The standby pumps shall be activated upon failure of duty pump(s).
- e. In event of control failure, the pumps shall be able to be start/stopped manually at the local panel by means of pressure switches.
- f. The microprocessor control panel shall be able to cut-off the pumping system when excess pressure is registered in the discharge common manifold.
- g. The system shall have the capability of receiving input signal concerning reduced water level in suction tanks and shall have control mechanisms to prevent the pumps from running dry.
- h. Automatically starting the pumps when the water level is back to normal.
- i. In case of pump failure due to motor overload, the standby pump is switched on automatically. Alarm signal is displayed on the LCD Display unit and alarm lights are activated.
- j. Functions to limit the no. of start/stop of pumps per hour.
- k. The system control panel shall incorporate LCD Display.
- l. The system control panel shall be IBMS compatible, with potential free contacts

having RS 485 ports for monitoring the on/off status.

3.3.6 OPERATION OF CONTROL PANEL

AUTO MODE

The desired delivery pressure within the range specified shall be set at the control panel. The differential pressure transmitter shall detect the delivery pressure continuously and give feedback to the microprocessor which will control the variable speed drive frequency converter for speed control of the duty pump. When demand increases, the subsequent pumps in the system will be activated to boost up the pressure. Ultimately the duty pump set shall be operated fully automatically to maintain the delivery pressure constantly at the desired set value.

MANUAL MODE

The on/off function of the pumps shall be manually adjusted at the microprocessor located at the local control panel.

FREQUENCY CONTROL BY-PASS MODE

All the pump sets shall be started/stopped automatically with the pump output at fixed maximum rotational speed. All the control and protection functions shall remain active. The cut in/cut out pressure shall be internally calculated by the microprocessor for each pump.

IBMS COMPATIBILITY:

The control panel shall be mounted on wall / floor, in a control cabinet with an IP 67 enclosure of suitable rating having Potential free contacts to monitor on/Off & Trip status with necessary sensors/switches.

ELECTRICAL COMPONENT

For Electrical works - "Please refer electrical specifications provided as part of tender document"

METHOD OF STARTING

The panel shall be built to start the pumps in suitable starting modes, i.e. D.O.L.,

Star/Delta, or using Soft Starters.

3.3.7 PUMP PRESSURE VESSEL

- a. Diaphragm type pressure vessels shall be provided as shown on the drawings. They shall be incorporated into the system so that during normal operation the pump shall not need start within 30 seconds of it switching off, to prevent the pump hunting.
- b. The pressure vessel shall be of adequate capacity to accommodate a considerable fluctuation in water demand by the system with minimum start/ stop cycles of the pumps. The vessel shall be constructed of steel plate built to ASME Standards for Unfired Pressure Vessel. A rubber diaphragm shall be provided in the vessel for separating the water and pre-charge nitrogen. The pre-charge pressure shall be adjustable and charging port with non-return device shall be provided. The adjustable cut-in and cut-off pressure unit for the pumps shall be built-in at the vessel to suit the system.-

3.3.8 ACCESSORIES

The system shall be provided with all accessories such as base plate, mounting pads, foundation bolts, foot valves, pressure gauge, pressure switches / pressure transmitter / transducer, level indicator, isolation valve for pressure vessel, etc. all accessories required for proper and safe operation shall be furnished with the pumps.

3.3.9 SUCTION AND DELIVERY PIPE, FITTINGS, FLANGES & VALVES

All suction, delivery and header pipe shall be GI & shall conform to IS: 1239, medium/heavy duty. Fittings shall be as per the pipe thickness. All pipes shall have flanges connection & pipe shall conform to BS 10, Table - D. All hardware shall be zinc plated. The system shall be equipped with suction & delivery valves flanged valves. On suction side ball/gate valve shall be provided while on delivery side ball/butterfly valves shall be provided. Also, spring operated check valves shall be provided on delivery side of each pump & on delivery header. In case of negative suction foot valve shall be provided for each pump suction or suction header as specified in data sheet. Flexible bellows shall be provided on suction & delivery side of each pump.

3.3.10 TESTING

- a. Hydrostatic test shall be carried out at 1.5 times the maximum discharge pressure.
- b. For electrical accessories, necessary tests shall be performed, or factory test certificate shall be furnished.

3.3.11 DRAWINGS

Following drawings shall be furnished by the Contractor.

- a. Overall dimensional drawing.
- b. Pump performance curves.
- c. Cross-sectional drawings.
- d. Panel GA drawing.
- e. Bill of Material and Material of Construction.

3.3.12 THE RATES ARE INCLUSIVE OF:

- a. Pump-Motor sets.
- b. Pressure vessel with isolation valves.
- c. Base plate, foundation bolts, anti-vibration pads.
- d. Pump suction – delivery pipe & suction & delivery manifolds.
- e. Foot valves in case of negative suction.
- f. Pump Suction isolation valve, Pump delivery & delivery manifold isolation valve & NRV, suction manifold isolation valve, pump suction & delivery flexible bellows.
- g. Pressure gauges, switches & panel mounted Pressure transmitter, level indicator to be interlocked with pump operation.
- h. Microprocessor based control panel with all electrical components, protections, interlocks, cable from control panel to pump.
- i. Variable frequency drives.

- j. All electrical accessories.
- k. All material like flanges, hardware, gaskets, etc. required for installation.
- l. Installation, testing & commissioning.
- m. Making all damage good to original condition after completion of work.
- n. All necessary labour, material and use of tools.
- o. Set of accessories such as pressure switches / pressure transducers, interconnecting power and control cabling etc. complete and set of accessories like NRVs, isolating valves, SS-304 (non-Magnetic) or MS CED coated suction and delivery header, pressure gauge, MS base frame (Synthetic enamel painted over a coat of primer).

3.4 SUMP PUMP:

3.4.1 SCOPE

The scope includes providing and fixing compact Monoblock dry motor submersible pumps of suitable rating, with non-clog or Vortex Type drainage Pumps with free flow open impeller, solid handling capacity of up to at least 25 mm suitable for operation on 415 volts +10%, 3 Phase, 50Hz, A.C supply, speed 2900 RPM including oil chamber, MS galvanized guide bar & MS assembly with SS 304 chain with shackle for 2 Nos. submersible drainage pumps in a sump of overall depth not more than 2.0 m.

3.4.2 DESIGN & CONSTRUCTION FEATURES

- a. These shall be fully submersible with a fully submersible motor.
- b. The pumps shall be provided with an automatic level controller and all interconnecting power and control cabling which shall cause the pumps to operate when the water level in the sump rises to a pre-set level and stop when the pre-set low level is reached. Pumps for drainage shall be single stage, single entry. Pump shall be C.I. casing and C.I. two vane open type with a dynamically balanced impeller connected to a common shaft of the motor.
- c. The vane for storm drainage pump, etc. it will be of semi open type.
- d. The MOC of the sump shall be in accordance to schedule of quantity. Stuffing box shall be provided with mechanical seals. Each pump shall be provided with a

suitably rated induction motor, suitable for 230 / 415 volts, single / three phase, 50 Hz A.C. power supply.

- e. Each pump shall be provided with in built liquid level controller for operating the pump between predetermined levels. The pumping set shall be for stationary application and shall be provided with pump connector unit. The delivery pipe shall be joined to the pump through a rubber diaphragm, and bend and guide pipe for easy installation.
- f. Pump shall be provided with all accessories and devices necessary and required for the pump to make it a complete working system.
- g. Sump pump shall be complete, with level controllers, power and control switchgear, Auto/off/Manual switches, pumps priority selections and control and power cabling up to motor and controller/probes etc. (Including earthing).
- h. Level control shall be such that one pump starts on required level, 2nd pump cuts in at high level and alarms is given at extra high level. All level controllers shall be provided with remote level indications.
- i. The pump sets shall be supplied with required accessories & as per specification with the following:
- j. Complete piping 80 mm dia common delivery up to 7.5 m in heavy Duty Class 'C' G.I. – 1 Set
- k. 50 mm dia Butterfly valve. – 2 units
- l. 50 mm dia Flap Type Non-return valve. – 2 units
- m. Necessary cables from pump set to control panel (position of panel marked on enclosed drawings). – 1 Set
- n. Electrical control panel having all necessary accessories & safety devices of standard specifications and suitable for receiving incomer cable to connect complete. (Panels with sump pumps near each sump as per site conditions). –1 unit.
- o. In addition to the above description sump pump shall have grinder/cutter system to provide high efficiency. After discharge solid handling shall be not more than 25 mm. Motor shall have built-in thermal protection against overheating.

- p. If PMC/Employer require, he may ask for a Factory Acceptance Test, and for this the contractor is bound to make the adequate arrangements for the factory visit at no extra charge.

3.4.3 MOTOR DESIGN

- c. The pump motor shall be a squirrel cage induction, housed in air filled watertight enclosure. Oil filled motors are not acceptable. The stator windings shall be Class "F" insulation (155 °C or 311 °F) for general usage and class 'H' insulation (180 °C or 317-8 grade 2) for submersible type.
- d. The stator shall be heat shrunk fitted into the enclosure and shall not use bolts, pins or other fasteners that penetrate through the stator enclosure. The starter shall be equipped with a thermal switch embedded in series in the coils of the starter windings to protect the stator from wheel.
- e. The motors shall be designed for continuous running duty type at 230/ 415 volts, 1/3 phase, 50 Hz power supply and capable of sustaining a minimum of 20 starts/stops per hour.

3.4.4 THE RATES ARE INCLUSIVE OF:

- a. Pump-Motor sets.
- b. Pump suction – delivery pipe & suction & delivery manifolds.
- c. Pump delivery & delivery manifold isolation valve & NRV.
- d. Level indicator to be interlocked with pump operation.
- e. Starter panel with all electrical components, protections, interlocks, cable from starter to pump.
- f. All material like flanges, hardware, gaskets, etc. required for installation.
- g. Installation, testing & commissioning.
- h. Making all damage good to original condition after completion of work.
- i. All necessary labour, material and use of tools.

3.5 SUMP PUMP DISCHARGE LINE**3.5.1 SCOPE**

- a. Class C GI pipe work (pipes cost will be paid separately) for all Sump Pump discharge line with common header complete with all fittings like butterfly valve, NRV, elbow, tee, reducer, flange, union etc. complete, conforming to IS:1239 (Part 1) for pipes and IS : 1879 (Part 1 to 10) for fittings including fixing in wall / ceiling / floor level, supported by galvanized clamps, hangers, vertical pipe support etc as per specification/drawings and as directed by Engineer In Charge. For submersible pump discharge pipe as per design drawing shall be installed at pump room Sump Pit.
- b. At discharge header from pump shall be fabricated with pipe butterfly valve and NRV.
- c. All pipe, Fitting, Valve & accessories shall be as per IS code.
- d. Dismantling joint shall be installed at pump discharge for easy operation & Maintenance.

4.0 LEVEL SENSOR & LEVEL CONTROLLER:**4.1 SCOPE:**

- a. This scope includes providing and fixing water level indicators cum controllers, for pump operations, working on hydrostatic pressure measurement principle made of Stainless Steel for installation in storage tanks, and capable of providing 4 to 20 mA analogue signals compatible with PLC signal inputs, including all wiring and piping as required complete as per working requirements for details of equipment below.
- b. These level sensors and panels are for operating the submersible pumps, Transfer pumps in the Underground Tanks, for filling of the Terrace Tanks, and the Motorized valves installed at the inlet of the tanks, as the case may be.
- c. The pumps would be provided with their respective starter panels, which have to be integrated with the level sensor panels, and Potential free contacts to monitor On /Off & Trip status.
- d. The scope includes integration of the pump starter panels, electrically actuated butterfly valves and level sensors.

- e. The level sensors would be located in the Terrace tanks and Underground Tanks, and the cabling from the terrace tanks to the submersible pump panel near the Underground tanks and underground tanks to the valves in the site, are included in this scope.
- f. All cabling, wiring, conduiting, etc required for this job are included in the scope.
- g. This scope also includes providing and fixing local level controllers near / on each overhead tank, comprising of control module and level sensor SS guide and float type, to close the Motorized valve Dia. Upto 200 mm, Solenoid valve (50mm dia and below), installed at the inlet line of the tank, when the level in the tank is high and open the valve when the level in the tank is low.
- h. The scope shall also include one number of bypass assembly including fittings, specials and flanges etc. as required. The complete set up shall be required to be installed just before the inlet of overhead tank which can be 10 - 15 feet above the roof top terrace level. The contractor should take this into account while quoting. It should be compatible with BMS System.

4.2 MATERIAL

The water level indicator shall be designed to operate on hydrostatic pressure measurement principle. The MOC shall be principally of Stainless-steel.

Remote Position Indicator:

- a. A 4-20 mA remote position analog signal transmitter shall be provided in the level sensor.
- b. The remote position indicator shall continuously indicate the status of the level indicator. Internal wiring for power and control circuits shall be appropriately sized for MOV actuator rating.
- c. Each wire shall be identified at both ends using PVC ferrules.
- d. The terminal compartment shall be separated from the inner electrical components of the level sensor by means of a watertight seal so that the sensor's electrical components are protected from the ingress of moisture and foreign materials when the terminal cover is removed during installation and maintenance.
- e. Contractor shall be solely responsible for the compatibility of the for the selection

and sizing of various electrical devices and components in the sensor.

- f. The sensor shall be provided with minimum three adequately sized cable entries viz., one for power cable and two for control cables.

All control outputs to MCC panel shall be included as per requirements.

All MCC panels should be provided with pedestals / wall mount facility and shall be installed.

All MCC Panels shall have weatherproof cabinets with IP - 65 for housing the level controller and electronic unit of level indicator, potential free contact for compatibility with BMS. complete as approved and specified.

4.3 TESTING

- a. The sensor shall be tested as per the relevant standard & duly stamped. Test certificate shall be submitted for material & hydraulic testing.
- b. Should the Engineer require, he may ask for a Factory Acceptance Test, and for this the contractor is bound to make the adequate arrangements for the factory visit at no extra charge.
- c. After fixing in the tanks, the system shall be hydraulically tested for 2 working days for any variations in the readings / operation of the solenoid valves. In case of fallouts the contractor shall rectify/replace sensors / valves at his own cost.

4.4 THE RATES ARE INCLUSIVE OF:

- a. Liquid Level Sensors with Analog Signal Transmitters of required type, and size.
- b. Fixing & jointing material.
- c. Electrical connections
- d. Data Cable connections with level sensors and BMS
- e. Making all damage good to original condition after completion of installation work.
- f. Testing.
- g. All necessary materials, labour and use of tools.

5.0 WATER DISTRIBUTION SYSTEM.

Work under this section consists of furnishing all labour, materials equipment and appliances necessary and required to completely install for water supply system (Domestic Water Supply + Flush Water Supply) as required by the drawings, specified hereinafter and given in the Schedule of Quantities.

Without restricting to the generality of the foregoing, the water supply system shall include the following:

- a. Domestic Water Main Distribution System from Municipal to Underground tank (U.G.T).
- b. Flushing Water, HVAC Makeup Water, Irrigation Main Distribution System from S.T.P. to U.G.T.
- c. Domestic Water Distribution System from U.G.T. to OHT
- d. Flushing Water Distribution System from U.G.T. to O.H.T
- e. Irrigation Water Distribution System from U.G.T. to Landscape.
- f. Rainwater Overflow Distribution System from U.G.T. to Storm water network.
- g. All water supply lines to various parts of the building including connection to vertical stack/ main source line.
- h. Pipe protection and painting.
- i. Providing hot water system & insulation of hot & cold-water pipelines wherever required.
- j. Connections to all plumbing fixtures, kitchen tanks, appliances, irrigation features, water bodies.
- k. Ball valve/butterfly valve/ Non-Return valve/Float valve/Pressure relief valve/Air valve, masonry chambers & other appurtenances.
- l. Supports/ Clamps, Excavation& refilling of pipe trenches, required civil work.
- m. Water meters, gauges, etc. required.

5.1 GENERAL REQUIREMENTS

- a. All materials shall be new and of the best quality conforming to specifications. All works executed shall be to the satisfaction of the Engineer
- b. Pipes and fittings shall be of fresh material & shall be fixed truly vertical, horizontal or in slopes as required in a neat workmanlike manner.
- c. Short or long bends shall be used on all main pipelines as far as possible. Use of elbows shall be restricted for short connections. As far as possible all bend shall be formed by means of a hydraulic pipe bending machine for pipe up to 65 mm diameter.
- d. Pipes shall be laid in a manner that provides easy accessibility for repair and maintenance and shall not cause obstruction in shafts, passage etc.
- e. Valves and other appurtenances shall be located to provide easy accessibility for operations, maintenance, and repairs.
- f. Pipe shall be securely fixed to wall and ceiling by suitable clamps at intervals specified.
- g. Tender drawings indicate schematically the size and location of pipes. The contractor on the award of the work shall prepare detailed working drawings, showing the cross-section, longitudinal sections, details of fittings, locations of isolating and control valves, drain valves and all pipe support, structural supports. He must keep in view the specific openings in buildings and other structures through which pipes are designed to pass.
- h. Pipe sleeves, 50 mm larger diameter than pipes, shall be provided wherever pipes pass through walls and slabs, and annular space filled with fibreglass and finished with retainer rings.
- i. All pipe work shall be carried out in a workman like manner, causing minimum disturbance to the existing services, buildings, roads and structure. The entire piping work shall be organized in consultation with other agencies work so that the area work shall be carried out in one trench.
- j. Cut outs in the floor slab for installing the various pipes are indicated in the drawings. Contractor shall carefully examine the cut outs provided and clearly point out wherever the cut outs shown in the drawings, do not meet with the

requirements.

- k. The contractor shall make sure that the clamps, steel structural supports brackets, clamp saddles and hangers provided for pipe supports are adequate.

WATER SUPPLY PIPING MATERIAL			
MUNICIPAL TO UGT	STP TO UGT	UGT TO OHT	TERRACE LOOP
Centrifugally cast (spun) Ductile Iron pipe with tyton jointed class "K9" conforming to IS 8329 with class K12 fittings conforming to IS 9523	HighDensity Poly Ethylene (HDPE-PE-63) pipes conforming to IS 4984	uPVC scheduled 80 pipe conforming to ASTM D 1785 and fitting scheduled 80 conforming to D 2567	uPVC scheduled 80 pipe conforming to ASTM D 1785 and fitting scheduled 80 conforming to D 2567
DOWNTAKE	INTERNAL TOILET	HOT WATER	SUMP PIT
uPVC scheduled 80 pipe conforming to ASTM D 1785 and fitting scheduled 80 conforming to D 2567	cPVC Up to 50 mm : SDR-11, Pipes as per IS15778/D2846 and fittings as per ASTMD2846 - SDR 11	Copper Tubes conforming to EN 1057 complete with End Feed Type Capillary Fittings in accordance with EN 1254-1	Heavy class (Class C) G.I. pipes conforming to IS:1239 (All fittings shall conform to IS:1879 - part 1 to 10)

5.2 SYSTEM TESTING

All pipes, fittings & valves shall be tested by hydrostatic pressure of 16 kg/cm² or 1.5 times working pressure whichever is higher. Pressure shall be maintained for at least 2 hrs. A test register shall be maintained & all entries shall be signed & dated by contractor & PMC/Employer.

In case of sectional testing carried out during construction, contractor shall test the entire installation after connections to the overhead tanks or pumping system or mains. He shall rectify all leakages & shall replace defective materials in the system. Any damage done due to carelessness, open or burst pipes or failure of fittings to the building, furniture & fixtures shall be made good during defect liability period without any extra cost. All hot water supply & return piping shall be checked for proper insulation.

After completion the water supply system, contractor shall test each valve by closing & opening it many times to observe it's working. Valves which do not effectively operate shall be replaced by new ones at no extra cost & same shall be tested as above.

5.3 FERRULE

The ferrules for connection with main shall generally conform to IS 2692. It shall be of non-ferrous materials with a bell mouth cover && shall be of nominal bore as specified.

The ferrule shall be fitted with a screw & plug or valve capable of completely shutting of the water supply to the communication pipe as & when required.

For fixing, the empty mains shall be drilled & tapped at 45 degree to the vertical & ferrule screwed in. The ferrule must be so fitted that no portion of the shank shall be left projecting within mains into which it is fitted.

5.4 DISINFECTION/ STERILISATION OF PIPING & TANK

Before commissioning of water supply system, the contractor shall arrange to disinfect the entire system.

Water storage tanks & pipes shall first be filled with water & thoroughly flushed out. The storage tanks shall then be filled with water again & disinfecting chemical containing chlorine shall be added gradually while tanks are being filled to ensure thorough mixing. Sufficient chemical shall be used to give water a dose of 50 parts of chlorine to one million parts of water.

If ordinary bleaching powder is to be used, the proportion shall be 150 gm of powder in 1000 litre of water. The powder shall be mixed with water in storage tank. For any other chemical, the proportion shall be as recommended by the manufacturer. When the storage tank is full, the supply shall be stopped; all tapes on distributing lines shall be opened successively. Each tap shall be closed when water discharged shall begin to smell chlorine. The storage tank shall then be filled with supply pipe with more disinfecting chemicals in recommended proportion. The storage tank & pipe shall remain charged for at least 3 hours. Finally, tank & piping shall be thoroughly flushed out before water is to be used for domestic application.

5.5 PRE-COMMISSIONING

- a. Ensure that all pipes are free from debris & obstructions.
- b. Check all valves for effective on-off operation.
- c. Ensure that all connections to branches are made.
- d. Ensure connection of mains to UG tank, Pumps & OH tank as per requirement.
- e. Water supply shall be available at underground tank.
- f. Ensure that all line valves shall be closed.

5.6 TESTING & COMMISSIONING

- a. Disinfect Storage tanks & piping.
- b. In case of borewell supply, start pump & fill underground water tank. Water shall first enter fire compartment & then fill domestic compartment.
- c. Start domestic pump to fill OH tank. After filling the OH tank, drain the tank to its $\frac{1}{4}$ the capacity by opening the drain valve. This is to ensure removal of silt, mud, debris, etc. Again, fill OH tank to full.
- d. Release water in each line by opening the line valves, flush out whole piping system & ensure clear water is now coming out of the system.
- e. Observe valves for any leakage. Check the pressure at pump & at farthest utility points.

5.7 PRESSURISED PIPE TESTING

- a. The Contractor shall notify the PMC/Employer three days in advance of any test so that the PMC/Employer can witness the tests if he so wishes.
- b. All water supply system shall be tested to hydrostatic pressure test of at least one and a half (1.5) times the maximum pressure but not less than 16Kg/Sq.cm for a period of not less than 8 hours. All leaks and defects in joints revealed during the testing shall be rectified and got approved at site by retest. Piping required subsequent to the above pressure test shall be retested in the same manner.
- c. System may be tested in sections and such sections shall be entirely retested on completion.
- d. The Contractor shall make sure that proper noiseless circulation of fluid is achieved through the entire piping network of the system concerned. In case of improper circulation, the contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications including the tearing up and refinishing of floors and walls as required.
- e. In addition to the sectional testing carried out during the construction, contractor shall test the entire installation after connections to the overhead tanks or pumping system or mains. He shall rectify all leakages and shall replace all defective materials in the system. Any damage done due to carelessness, open or burst pipes or failure of fittings, to the building, furniture and fixtures shall be made good by the

contractor during the defects liability period without any cost.

- f. After commissioning of the water supply system, contractor shall test each valve by closing and opening it a number of times to observe if it is working efficiently. Valves which do not effectively operate shall be replaced by new ones at no extra cost and the same shall be tested as above.
- g. A test register shall be maintained and all entries shall be signed and dated by Contractor(s) and PMC/Employer's site representative.

NOTE: - ALL CP FITTINGS & SANITARY WARE SHALL COMPLY TO LOW FLOW FIXTURE AS MENTIONED IN SANITARY WARES BOQ

5.8 UPVC / CPVC Pipe

5.8.1 CPVC Piping:

Chlorinated Polyvinyl Chloride pipes (CPVC) up to 50mm dia SDR.11, CTS, as per IS 15778/D2846, and 50mm dia above CPVC schedule 40 ASTM F441, IPS. Fittings up to 50mm dia SDR.11 ASTM D2846, and Fittings above 50mm dia shall be SCH 80 ASTM F-439. Where connection with metal is to be made in such case the fittings and specials such as tees, elbows, couplers, bends, enlargers etc, shall have brass threaded (male/female), brass coupling, Brass FPT, Brass male adaptor etc confirming to ASTM D2846. The piping works shall be supported with proper metal/CPVC clamps, Tee holders, elbow holders and supports etc., Include necessary drilling holes, chasing walls and making the same good in cement mortar 1:1 restore the same original condition neatly as directed by the Engineer in-charge. Joints to be made with CPVC solvent cement up to 50mm dia as per ASTM F-493 and above 50mm dia primer P-70, and solvent confirming to ASTM F-493 / CPVC 724. All exposed pipes to be painted with one coat of desired shade of enamel paint as per architect/client representative requirement. All termination points for installation of faucets shall have brass termination fittings.

CPVC ASTM D2846, SDR 11 Plastic Pipe							
Nominal Size		Outside Diameter, in. (mm)		Wall Thickness, in. (mm)		Pressure Rating. PSI (Kg/Cm ²)	
(in.)	(mm)	Average	Tolerance	Minimum	Tolerance	(23°C)	82°C
½	(15)	0.625 (15.9)	±0.003 (±0.08)	0.068(1.73)	+0.020 (+0.51)	(28.1)	(7.0)

¾	(20)	0.875 (22.2)	±0.003 (±0.08)	0.080(2.03)	+0.020 (+0.51)	(28.1)	(7.0)
1	(25)	1.125 (28.6)	±0.003 (±0.08)	0.102(2.59)	+0.020 (+0.51)	(28.1)	(7.0)
1 ¼	(32)	1.375 (34.9)	±0.003 (±0.08)	0.125(3.18)	+0.020 (+0.51)	(28.1)	(7.0)
1 ½	(40)	1.625 (41.3)	±0.004 (±0.10)	0.148(3.76)	+0.020 (+0.51)	(28.1)	(7.0)
2	(50)	2.125 (54.0)	±0.004 (±0.10)	0.193(4.90)	+0.023 (+0.58)	(28.1)	(7.0)

Outside Diameters and Wall Thickness for CPVC SCHEDULE 40 (AS PER ASTM F 441)					
Nom (in.)	Size (mm)	Average OD (mm)	Min. Wall Thick	Max. work Pre. At 23°C (kg/cm²)	
2 ½"	65	73.02	5.16	21.09	
3"	80	88.90	5.49	18.28	
4"	100	114.30	6.02	15.47	
6"	150	168.28	7.11	12.66	
8"	200	219.08	8.18	11.25	
10"	250	273.05	9.27	9.84	
12"	300	323.55	10.31	9.14	

5.8.2 UPVC PIPING (WATER SUPPLY – EXPOSED & NON-EXPOSED):

Un plasticized polyvinyl chloride water supply pipes schedule- 80 ASTM D1785 at a working pressure not less than 600 PSI for 15 mm to 180 PSI for 150 mm at 23 deg C,. The pipes shall be jointed using solvent welded SCH 80 uPVC fittings i.e. Tees, Elbows, Couplers, Unions, Reducers, brushings etc confirming to ASTM D-2467. The transition fittings connection between uPVC & metal pipe/GI shall be Brass Adaptors (both Male & Female threaded), brass tee, brass elbow etc conforming to ASTM D- 2467. The solvent joint shall be done with solvent cement conforming to ASTM D-2564. The piping works shall be supported with clamps, hangers, anchor fasteners, structural steel supports as required / directed at site including cutting chases and fitting the same with cement concrete / cement mortar as required. All termination points for installation of faucets shall have brass termination fittings. Installation shall be to the satisfaction of Project Manager /Consultant / manufacturer of pipes & fittings.

5.8.3 JOINING PIPES & FITTINGS

- I. **Cutting:** Pipes shall be cut either with a wheel type plastic pipe cutting or hacksaw blade and care shall be taken to make a square cut which provides optimal bonding area within a joint.
- II. **De burring / Bevelling:** Burrs and fittings should be removed from the outside and inside of pipe with a pocketknife, debarking tool or file otherwise burrs and fittings may prevent proper contact between pipe and fittings during assembly.
- III. **Fitting preparation:** A clean dry rag/cloth should be used to wipe dirt and moisture from the fitting sockets and tubing end. The tubing should make contact with the socket wall 1/3 or 2/3 of the way into the fitting socket.

IV. Solvent Cement Application:

- a) **CPVC:** Joints to be made with CPVC solvent cement up to 50mm dia as per ASTM-F- 493 and above 50mm dia primer P-70, and solvent confirming to ASTM F-493 & CPVC 724.

Only CPVC solvent cement confirming to ASTM-F493 should be used for joining pipe with fittings. An even coat of solvent cement should be applied on the pipe end and a thin coat inside the fitting socket, otherwise too much of cement solvent can cause clogged water ways. CPVC cement solvent have a minimum shelf life of 1 year. Aged cement solvent will often change colour or being to thicken and become gelatinous or jelly like and when this happens, the cement should not be used. The cement solvent should be used within 30 days after opening the company's seal and tightly close the seal after using in order to avoid its freezing. The freezed cement solvent should be discarded immediately and fresh one should be used. The CPVC solvent cement usage should be adhered to as given in table below.

Diameter of pipe in inch (flow guard)	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
Approx. nos. of joints which can be mode per litre of solvent cement.	200 Nos	180 Nos	150 Nos	130 Nos	100 Nos	70 Nos

- b) **uPVC:** The solvent joint shall be done with solvent cement conforming to ASTM D-2564. Insert the pipe into the fitting and check to that the interface occur about 1/3rd to 2/3rd of the socket depth. Application of solvent cement – Apply cement lightly but uniformly to inside of socket and outside of pipe end with suitable

applicator. Immediately after applying the last coat of cement to the pipe and while the cement is still fluid or wet, forcefully bottom the male end of the pipe in the socket, giving pipe or fitting $\frac{1}{4}$ turn (but not after pipe is bottomed) to distribute the cement evenly. Remove excess cement from the end of the fitting socket. The joint must not be disturbed immediately after cementing so that the joint can be properly cured.

- V. Assembly: After applying the solvent cement on both pipe and fitting socket, pipe should be inserted into the fitting socket within 30 seconds, and rotating the pipe $\frac{1}{4}$ to $\frac{1}{2}$ turn while inserting so as to ensure even distribution of solvent cement with the joint. The assembled system should be held for 10 seconds (approximately) in order to allow the joint to set up.
- VI. An even bead of cement should be evident around the joint and if this bead is not continues remake the joint to avoid potential leaks.

5.8.4 SUPPORT SPACING:

To ensure satisfactory operation of system pipe support shall be installed as follows: All pipes shall be supported with approved hangers at intervals as shown in below tables. Pipe shall be supported at all branch ends and change of directions apart from straight lines. Concentrated loads should be supported directly/support the pipe immediately adjacent to the load. Allowance must be provided for temperature fluctuations. Hangers should not restrict the pipe movement to allow pipe contraction/expansion.

SDR-11, SCHEDULE - 40 /CPVC

Recommended Support spacing (in feet)

Nom. Pipe Size		Temperature			
(In)	(mm)	23	38	49	60
$\frac{1}{2}$	15	4	4	2 $\frac{1}{2}$	2 $\frac{1}{2}$
$\frac{3}{4}$ to 1"	20 - 25	5	4 $\frac{1}{2}$	4	2 $\frac{1}{2}$
1 $\frac{1}{4}$ to 2"	32 - 50	5	5	3	3
2 $\frac{1}{2}$	65	7 $\frac{1}{2}$	7	7	6 $\frac{1}{2}$
3	80	8	7	7	7
4	100	8 $\frac{1}{2}$	7 $\frac{1}{2}$	7 $\frac{1}{2}$	7
6	150	9 $\frac{1}{2}$	8	8	7 $\frac{1}{2}$

8	200	9 ½	8	8	7 ½

SCHEDULE - 80

Recommended Support spacing (in feet)

Nom. Pipe Size		Temperature			
(In)	(mm)	23	38	49	60
½	15	4 ½	4 ½	3	2 ½
¾ to 1"	20 - 25	5 ½	5 ½	3½	3
1 ¼ to 2"	32 - 50	6	5	3½	3½
2 ½	65	8	7 ½	7 ½	6 ½
3	80	8	8	7 ½	7
4	100	9	9	8 ½	7 ½
6	150	10	9 ½	9	8

5.8.5 TESTING

Once an installation is completed and cored as per above mentioned recommendations, the system should be hydrostatically pressure tested at 1.5 times working pressure or 150 psi(10 Bar) whichever is higher for one hour. During pressure testing, the system should be fitted with water and if a leak is found, the joint should be cut out and replacing the same with new one by using couplers.

5.9 GI PIPES IS 1239**5.9.1 SCOPE**

The item includes supplying of G.I. pipes with fittings including laying, fixing, cutting, joining, painting etc.

5.9.2 MATERIAL

- Galvanised steel pipe shall conform to IS: 1239 /3589 of size & class as specified in bill of quantities. When Class is not specified they shall be Heavy Class. Hot dip galvanising shall be as per IS 4759.
- Fittings shall be of malleable cast iron galvanized of approved make. Each fitting shall have manufacturer's trade mark stamped on it. Fittings for G.I pipes shall include couplings, bends, tees, reducers, nipples, unions, bushes etc. Fittings etc. shall conform to IS: 1879. (Part I to X) with latest edition.

5.9.3 JOINTING & FIXING

- a. Pipes and fittings shall be jointed with screwed joints using Teflon tape suitable for water pipes. Care shall be taken to remove burr from the end of the pipe after cutting by a round file. All pipes shall be fixed in accordance with layout and alignment shown on the drawings. Care shall be taken to avoid air pockets. Necessary vents and drains shall be provided at all high and low points respectively. G.I pipes inside toilets shall be fixed in wall chases well above the floor. No pipes shall be run inside a sunken floor as far as possible. Pipes may be run under the ceiling or floors and other areas as shown on drawings.
- b. Piping shall be properly supported on or suspended from clamps, hangers as specified and as required. The contractor shall adequately design all the brackets, saddles, anchors, clamps and hangers and be responsible for their structural sufficiency.
- c. All pipe clamps, supports, hangers, pipe support shall be factory made galvanized MS steel or alternatively galvanized/ anti rust coating after fabrication to suit site requirement pipe supports. Pipe supports shall be adjustable for height where pipe and clamps are of dissimilar materials a gasket shall be provided in between. Spacing of pipe supports shall not exceed the following:

Sr. No.	Pipe Size	Spacing between Supports
1	Up to 12 mm	1500 mm (1.5m)
2	15 to 150 mm	2000 mm (2.0 m)
3	150 mm & over	2500 mm (2.5m)

- d. G.I pipes in shafts and other locations shall be supported by clamps of design approved by the PMC/Employer. Pipes in wall chases shall be anchored by iron hooks. Pipe sat ceiling level shall be supported on structural clamps fabricated from MS structural steel. Pipes in shafts shall be supported on slotted angles/ channels as specified/ as directed.
- e. Vertical risers shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars steel structural supports attached to pipe and with a 15-mm thick rubber

pad or any resilient material. Where pipes pass through the terrace floor, suitable flashing shall be provided to prevent water leakage. Risers shall have a suitable clean out at the lowest point and air vent at the highest point.

ANCHOR FASTENERS:

- f. All pipe supports, hangers and clamps to fixed on RCC walls, beams, columns, slabs and masonry walls 230 mm thick and above by means of galvanised expandable anchor fasteners in drilled holes of correct size and model to carry the weight of pipes. Drilling shall be made only by approved type of power drill as recommended and approved by manufacturer of the anchor fasteners. Failure of any fastening devices shall be the entire responsibility and contractor shall redo or provide additional supports at his own cost. He shall also compensate the PMC/Employer for any damage that may be caused by such failures.

Unions:

- g. Contractor shall provide adequate number of unions on all pipes to enable easy dismantling later when required. Unions shall be provided near each gunmetal valve, stop cock or check valve and on straight runs as necessary at appropriate locations as required for easy dismantling and/or as directed by Engineer.

Flanges:

- h. Flanged connections shall be provided on pipes as required for maintenance/ease in dismantling or where shown on the drawings, all equipment connections as necessary and required or as directed by the Engineer. Connections shall be made by the correct number and size of the GI nuts/ bolts as per relevant IS Standards and made with 3mm thick insertion rubber washer/gasket. Where hot water or steam connections are made insertion, gasket shall be of suitable high-temperature grade and quality approved by the Engineer. The diameter of the hole for bolt in flanges shall conform to match the specification for CI sluice valve as per relevant IS Gaskets shall conform to IS: 639.
- i. Expansion joints shall be provided wherever necessary to take due care for expansion and contraction in the pipe

SAND FILLING:

- j. GI Pipes in trenches shall be protected with fine sand 150mm all around before filling in the trenches.

THRUST BLOCKS:

- k. In case of bigger pipes (80 mm diameter and above), thrust blocks of cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregates of 20 mm nominal size) shall be constructed on all bends as directed by the PMC/Employer.

5.9.4 PAINTING

All pipes above ground shall be painted with one coat of red oxide and two coats of synthetic enamel paint of approved shade and quality. Pipes shall be painted to standard colour code IS:2379:1990 as specified by the Engineer.

5.9.5 PIPE PROTECTION

Where specified in the schedule of quantities all pipes in chase below ground shall be protected against corrosion by applying two coats of bitumen paint wrapping with polythene tape and finishing with one more coat of bitumen paint.

5.9.6 TESTING

- a. The openings of the pipes shall be sealed for the section to be tested. All control valves shall be positioned open for the duration of the test and open end closed with water tight fittings. The testing pressure on completion of the work shall not be less than 1.5 times the working pressure of the pipes or 7.5 Kg/Sq.cm whichever more is.
- b. Pressure shall be applied either by hand pump or power-driven pump. Pressure gauges shall be calibrated, correctly positioned and closely observed to ensure that at no time are the test pressure exceeded. The systems shall be slowly and carefully filled with water to avoid surge pressure or water hammer. Air vents shall be open at all high points so that air may be expelled from the system during filling.
- c. When the system has been fully charged with water and air displaced from the line air vent shall be closed and the line initially inspected for seepage at joints and

firmness of supports under load. Pressure is reached. Without any additional requirement of make-up-water the test pressure should not fall more than 0.02 MPa (0.2 kg. /sq.cm) at the end of one-hour test duration.

- d. The water pressure shall be maintained for minimum of two hour with accurate pressure gauge. The engineer shall examine carefully all the joints for leakage. Any joint found leaking shall be redone, and all leaking pipes removed and replaced without extra cost.

5.9.7 RATES

- a. G.I. Pipes and fittings of specified diameter & pressure class.
- b. Laying and cutting the pipe wherever necessary and wastage.
- c. Underground installation with all necessary civil work if specified in bill of quantities like excavation, dewatering, backfilling, bedding, encasing, etc.
- d. Or over ground installation with supports/clamps, accessories required.
- e. Pipe & Fitting with insulation for hot water application if specified in schedule of quantities
- f. Jointing & fixing material.
- g. Making all damage good to original condition after completion of installation work.
- h. Testing the entire system and rectification of defects if any.
- i. Painting the pipe line for over ground installation & pipe protection with coating & wrapping coating if mentioned in schedule of quantities.
- j. All necessary materials, labour and use of tools.

5.10 COPPER PIPES CONCEALED & EXPOSED:

- a. Copper tubes conforming to EN:1057 in ft. length and thickness as per Table 'X'. Dimension shall be strictly as per EN:1057 & Chemical Composition of copper pipes to be as follows:

Copper % - 99.9%

Phosphorus % - 0.015% to 0.040%

- b. For sizes 15mm and above, hard drawn tubes will be used. The tubes shall be totally cylindrical and of uniform thickness free from flaw, pin holes, cracks and other skin defects. The maximum working and burst pressure of tubes shall be as EN:1057. All tubes shall be eddy current tested to ensure the tubes are free from any internal blow holes / flaw or eccentricity. Tubes from manufacturers who do not have eddy current testing facility shall not be accepted. The buyer / user reserves the right to inspect the facility of the manufacturer to ensure that eddy current testing facility is prevalent and being done. Carbon film or Carbon content test must be conducted on Copper Tubes as per EN:1057.

The sizes and dimensions for Table “X” are as follows:

Tube Size	Outer Diameters		Thickness	Inner dia	Calculated Burst pressure ¹¹		Maximum Working Pressure	
	Max.	Min.						
(mm)	(mm)	(mm)	(mm)	(mm)	(bar)	(PSI)	(bar)	(PSI)
15	15.045	14.965	0.7	13.6	240	3480	58	841
22	22.055	21.975	0.9	20.2	215	3117.5	51	739.5
28	28.055	27.975	0.9	26.2	165	2392.5	40	580
35	35.07	34.99	1.2	32.6	175	2537.5	42	609
42	42.07	41.99	1.2	39.6	145	2102.5	35	507.5
54	54.07	53.99	1.2	51.6	110	1595	27	391.5
67	66.75	66.60	1.2	64.6	105	1522.5	20	290
76.1	76.30	76.15	1.5	73.1	100	1450	24	348
108	108.25	108.00	1.5	105	70	1015	17	246.5
133	133.50	133.25	1.5	130			14	203
159	159.50	159.25	2.0	155			15	217.5

CAPILLARY FITTINGS:

5.10.1 SCOPE

Fitting made of Dezincification Resistance materials i.e. Copper, DZR Brass (Alloy CZ 132) or Gun Metal conforming to BS:864 / EN:1254. Ordinary or Duplex Brass fittings are not allowed to be used. Dimensions of fittings shall conform to EN:1254 Part II and EN:1057 to ensure proper jointing. The distance between the socket and neck of the

fitting shall be sufficient to allow proper capillary action and flow of lead free solder. Threads on all fittings must be BSP threads and all male threads must be tapered and female ends parallel. Fittings must have BS:864 or EN:1254 imprinted on the fitting itself.

All fittings shall be embossed with the BS symbol mentioning the specification BS:864 or with EN:1254.

- a. 15mm to 28mm sizes Integral Solder Ring Fittings shall be used for all internal services.
- b. Sizes 35mm & above, End feed fittings shall be used for all external services.
- c. Fittings of sizes 15mm to 28mm shall be joined with copper pipes by the use of soft lead free solder wire as per the specification mentioned below.
- d. For fitting for sizes 35mm & above, the process of jointing shall be by brazing as per details given below. Under no circumstances fittings below 35mm shall be brazed and under no circumstances fittings of 35mm & above shall be soft soldered.

END FEED FITTINGS:

The fittings must be capable of End feeding. Solder Wire shall be used with these fittings must be soft solder capable of melting at approx. 230°C & must confirm to BS:219 / EN BS 29453. Solder Wire shall be absolutely lead-free. Only Copper Tin and Silver Tin Solder shall be acceptable. All fittings of 35mm and above shall be of End Feed Type.

SOLDER RING FITTINGS:

All plain end of fittings shall be provided with enough amount of lead-free solder in the neck of the fitting itself to ensure proper capillary action. The solder shall be soft solder and lead-free with melting temperature of approx. 230°C and shall be capable of melting with an ordinary blow lamp and on melting shall be sufficient to form a complete leak proof joint to cover the annular space in between the tube and fitting from the socket of the fitting to the outside of the fittings. Solder must conform to BS:219 / BS

EN:29453 specification. All fittings of 15mm to 28mm shall be of integral Solder Ring Type.

A. SOLDER WIRE:

All integral solder ring fittings strictly shall be lead-free solder. In the case of End Feed Fittings lead-free, Tin-Copper or Tin Silver solder, as specified in BS:EN:29453 (Formerly BS:219) shall be used in potable water installations.

B. FLUX:

- a. Flux shall be Non-Acidic, Lead-free.
- b. The Flux shall be supplied in paste form packed in small Tin container of 500 gms or small packaging and shall have compatibility to use with Solder wire (Lead-free & as per BS:219 or equivalent).
- c. The Flux shall be water soluble and shall be used in recommended quantity. Excess use of Flux not recommended

5.10.2 MATERIAL

- a. Copper pipe shall conform to EN 1057 of size & class as specified in bill of quantities.
- b. End Feed Type Capillary Fittings (with KITE Mark/ WRAS approvals) in accordance with EN 1254-1 such as sockets, bends, elbows, tees, reducers, unions. All threaded adaptors shall be of DZR Brass material.

5.10.3 JOINTING & FIXING:

The copper pipes and fittings shall run in wall chase or ceiling or as specified. The fixing shall be done by means of standard pattern holder bat clamps keeping the pipes about 1.5 cm clear of the wall where to be laid on surface. Where it is specified to conceal the pipes, chasing may be adopted. For pipes fixed in the shafts, ducts, etc., there shall be sufficient space to work on the pipes with the usual tools. As far as possible, pipes may be buried for short distances provided adequate protection is given against damage and where so required special care shall be taken at joints. Where directed by the PMC/Employer's Site Representative / Engineer in charge, pipe sleeves shall be fixed

at a place the pipe is passing through a wall or floor for reception of the pipe and allow freedom for expansion and contraction and other movements. In case pipe is embedded in walls or floors, it shall be covered with a protective tape wrapped around the pipes & fittings.

Copper pipe shall be joined with approved above mentioned fittings confirming to BS:864 Part II and EN:1254. Care shall be taken to remove any bulk from the end of the pipes after cutting. Only fittings of the size suitable to the pipe shall be used. The ends of the tube shall be cut to the correct size using a tube cutter or a line bladed hacksaw. Care shall be taken to ensure that the ends of the tubes are cut perpendicular to the axis of the tube and that the ends remain undamaged and free of burrs. Any burrs remaining shall be removed with a smooth file. The external surface of the tube that shall go into the fitting shall be cleaned.

Flux shall be applied on the pipe surface ensuring even and uniform application. Insert the tube into the fitting and push home until the stop is reached. Wipe off excess flux with a soft cloth. Now the assembled joint shall be heated with a blow. Torch or any similar appliance that emits a clean, blue, soot free flame. The heat shall be turned off once complete ring of solder has appeared on the mouth of the fitting.

Concealed pipe work shall include chipping walls, fixing with clamps including wrapping with polytene sheet tape and making good the walls complete as specified by PMC/Employer.

5.10.4 PAINTING

All pipes above ground shall be painted with one coat of red oxide and two coats of synthetic enamel paint of approved shade and quality. Pipes shall be painted to standard colour code IS:2379:1990 as specified by the Engineer.

5.10.5 TESTING

- a. The openings of the pipes shall be sealed for the section to be tested. All control valves shall be positioned open for the duration of the test and open end closed with watertight fittings. The testing pressure on completion of the work shall not be less than 1.5 times the working pressure of the pipes.
- b. Pressure shall be applied either by hand pump or power-driven pump. Pressure gauges shall be calibrated, correctly positioned and closely observed to ensure that at no time are the test pressure exceeded. The systems shall be slowly and

carefully filled with water to avoid surge pressure or water hammer. Air vents shall be open at all high points so that air may be expelled from the system during filling.

- c. When the system has been fully charged with water and air displaced from the line air vent shall be closed and the line initially inspected for seepage at joints and firmness of supports under load. Pressure is reached. Without any additional requirement of make-up-water the test pressure should not fall more than 0.02 MPa (0.2 kg. /sq.cm) at the end of one-hour test duration.
- d. The water pressure shall be maintained for minimum of two hour with accurate pressure gauge. The engineer shall examine carefully all the joints for leakage. Any joint found leaking shall be redone, and all leaking pipes removed and replaced without extra cost.

5.10.6 RATES

- a. Copper pipes and fittings of specified diameter & pressure class.
- b. Laying and cutting the pipe wherever necessary and wastage.
- c. Underground installation with all necessary civil work if specified in bill of quantities like excavation, dewatering, backfilling, bedding, encasing, etc.
- d. Or over ground installation with supports/clamps, accessories required.
- e. Pipe & Fitting with insulation for hot water application if specified in schedule of quantities.
- f. Jointing & fixing material.
- g. Making all damage good to original condition after completion of installation work.
- h. Testing the entire system and rectification of defects if any.
- i. Painting the pipeline for over ground installation & pipe protection with coating & wrapping coating if mentioned in schedule of quantities.
- j. All necessary materials, labour and use of tools.

5.11 HOT WATER PIPING INSULATION

Insulation material for Pipe insulation shall be Closed Cell Elastomeric Nitrile Rubber or closed cell cross linked polyethylene foam. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.038 W/moK or 0.0313 Kcal / Mhr oC or 0.212 BTU / (Hr-ft²-oF/inch) at an average temperature of 40oC. The product shall have temperature range of –40 oC to 105oC. Density of material shall not be less than 0.06 gm/cm³. The insulation shall have fire performance such that it passes minimum CLASS 1 as per BS476 part 7 for surface spread of flame. Water vapour permeability shall not exceed 0.024 per inch (3 x 10⁻¹⁴ Kgs / m.sec.Pa). The material shall have approval from the consultant.

Thickness of the insulation shall be as specified for the individual application. Each lot of insulation material delivered at site shall be accompanied with manufacturer test certificate for thermal conductivity values. Samples of insulation material from each lot delivered at site may be selected by PMC/Employer's site representative and gotten tested for thermal conductivity and density at Contractor's cost All joints shall be sealed properly with adhesive, which shall provide similar vapour barrier as the original insulating material.

All hot water piping shall be insulated in the manner specified herein. Before applying insulation, all pipes shall be brushed and cleaned. Thermal insulation shall be applied as follows or as specified in drawings or schedule of quantity:

Pipe size (mm)	Thickness of Nitrile rubber insulation
15 mm to 25 mm	9 mm
32 mm to 50 mm	13 mm
65 mm and above	19 mm

5.12 HDPE PIPE

Providing and supplying of ISI Marked High Density Polyethylene (HDPE-PE-80) PN6 pipes and specials in standard length suitable for Potable water as per IS Specification no. 4984/1995 or its latest revision/ amendments including all local & central taxes & duties, freight charges, loading, unloading & conveyance to the site of work & stacking the same in closed shade duly protecting from sunrays, rain & theft or physical damage, etc. complete. material grade (Pressure Rating: PN04)"

Lowering, laying and jointing of HDPE pipes and specials of following class and diameter (By butt fusion welding method) including cost of conveyance from stores to site of works at all level including cost of labour, material, giving satisfactory hydraulic testing etc. comp.

Including all the fittings, laid above false ceiling, in shaft, landscape etc.; the work shall include wall/ floor chases and making good the same in cement mortar/ concrete, etc., complete. The quoted rate should include necessary supports like hanger supports, grip bolts and clamps, etc., as well as supplying and fixing GI slotted angle iron brackets, hangers, supports with necessary drilling holes to suit the insertion of pipe clamps, deburring, etc.,

Table 15066-1 Physical Property and Pipe Performance Requirements

Property Specification Units Minimum Values.

Property	Specification	Units	Minimum Values
Material Designation	PPI/ASTM	-	PE3408
Material Classification	ASTM D1248	-	III C 5 P34
Cell Classification	ASTM D3350	-	345434C
Hardness	ASTM D2240	Shore D	64
Compressive Strength (Yield)	ASTM D695	psi	1,600
Tensile Strength @ Yield (Type IV Spec.)	ASTM D638 (2%/min)	psi	3,200
Elongation @ Yield	ASTM D638	%, min	8
Tensile Strength @ Break (Type IV Spec.)	ASTM D638	psi	3,500

Elongation @ Break	ASTM D638	%, min	600
Modulus of Elasticity	ASTM D638	psi	110000
ESCR:			
Cond A, B, C: Mold Slab.	ASTM D1693	Fo, Hrs	Fo>5,000
Compressed Ring)	ASTM F1248	F50, Hrs	F50>1,000
Slow Crack Growth	Battelle	-	Fo>32
Impact strength			
(IZOD) (0.125-inch thick)	ASTM D256	in-lb/in	
	(Method A)	Notch	42
Linear Thermal	ASTM D696	-	-
Expansion Coeff	ASTM D696	in/in/°F	-
Thermal Conductivity	ASTM C177	BTU, in/ ft2/hrs/°F	-
Brittleness Temp	ASTM D746	°F	<-180
Vicat Soft. Temp	ASTM D1525	°F	+257
NSF Listing	Standard 61	-	Listed

5.12.1 NIPPLES AND FLANGED STUB ENDS

Short nipples and stub ends shall be of the same material as the HDPE pipe.

5.12.2 FITTINGS

- a. Fittings shall be made from material meeting the same requirements as the pipe. Fittings shall be fabricated by the manufacturer of the pipe.
- b. Moulded fittings shall be manufactured in accordance with ASTM D3261 and shall be so marked.
- c. Mechanical fittings, when used, shall be specifically designed for, or tested and found to be acceptable for use with HDPE pipe.
- d. Fittings used to connect with dissimilar pipe materials shall be provided as per Section 15062 "Ductile Iron Pipe and Fittings."

5.12.3 JOINTS

Sections of polyethylene pipe shall be joined into continuous lengths on the job site above ground. The joining method shall be electro fusion method and shall be

performed in strict accordance with the pipe manufacturer's recommendations. The electro fusion equipment used in the joining procedures shall be capable of meeting all conditions recommended by the pipe manufacturer. electro fusion joining shall result in joint weld strength equal to or greater than the tensile strength of the pipe. Extrusion welding or hot gas welding of HDPE shall not be used. Flanges, unions, grooved-couplers, transition fittings, and some mechanical couplers may be used to connect HDPE pipe mechanically without butt-fusion only where shown in the Drawings.

5.13 DUCTILE IRON (DI) PIPES AND FITTINGS

Ductile iron pressure pipes and fittings shall be Class K9 (Pipe) / K12 (fittings) unless otherwise shown on the drawings and shall comply with IS: 8329 and IS: 9523. All fittings shall be socketed unless specified otherwise. Ductile iron pipes and fittings spigot and socket type shall be used for Municipal water piping works inside building.

Material - The materials used in the manufacture of pipes and fittings shall comply with IS: 8329 and IS: 9523. All fittings shall be socketed unless otherwise specified.

The materials used in the manufacture of pipes and fittings shall comply with IS: 8329 and IS: 9523. All fittings shall be socketed unless otherwise specified.

5.13.1 INSTALLATION

- a. DI pipes (Class K9) and DI fittings (Class K12) with internal Cement Mortar lining shall be in accordance with IS: 8329 and IS: 9523. Pipes shall be ISI marked.
- b. Pipes and fittings shall be procured from reputed manufacturers with Engineer's approval. Engineer shall at all reasonable times have free access to the place where the pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.
- c. The pipes will be centrifugally cast (spun) Ductile Iron pipes for Water and Sewage as per relevant ISO (amended up to date) having specifications/ properties equal to or superior to the IS: 8329 - 2000 (amended up to date). The pipes used will be with push on joints (Rubber Gasket Joints).
- d. The flange connection shall be used only in cases of fittings or specials or under special circumstances as directed by Engineer. The pipes shall be externally coated with bitumen as per Appendix C of the IS: 8329 - 2000 and have factory provided cement mortar lining in the inside as per the provisions of Appendix B of

the IS; 8329 - 2000.

- e. The pipes shall be supplied in standard length of 5.50- and 6.00-meters length with suitably rounded or chamfered ends. Each pipe of the push on joint variety shall also be supplied with a rubber ring (EPDM/ SBR) gasket. Any change in the stipulated lengths will be approved by the Engineer. The gaskets will confirm to the IS: 5382 - 1985 and IS: 12820.
- f. The manufacturer of the pipes should also supply the specials and gaskets. The manufacturer of the pipes should preferably manufacture them. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under its own supervision and have it tested at his/ sub contractor's premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.
- g. The flanged joints will confirm to the clause 6.2 of IS: 8329. The pipe supply will also include one rubber gasket for each flange.
- h. All tests specified either in this specification or in the relevant Indian Standards specified above shall be performed by the Supplier/ Contractor at his own cost and in presence of Engineer, if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to Engineer.
- i. If the test is found unsatisfactory, Engineer may reject any or all pipes and fittings of that lot. The decision of Engineer in this matter shall be final and binding on the Contractor and not subject to any arbitration or appeal.
- j. The pipes and fittings shall be stripped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects. Any defect in pipes and fittings in the opinion of Engineer shall be rejected and shall be replaced by new one.
- k. In the case of spigot and socket pipes and fittings the socket shall be without the centering ring.
- l. In the case of flanged pipes, the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the center line. The bolt hole circle shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

- m. All the DI fittings shall be supplied with one rubber ring for each socket.

5.13.2 DIMENSIONS AND TOLERANCES

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS: 8329/ IS: 9523 for different class of pipes and fittings. Standard length of 6 m of pipe is recommended and other properties for pipes and fittings shall be as per IS: 8329/ IS: 9523. Each pipe supplied shall be of uniform thickness throughout its length. The tolerances for pipes and fittings regarding dimensions, mass, ovality and deviations from straight line in case of pipes shall be as per IS: 8329/ IS: 9523.

5.13.3 LUBRICATION FOR DI PIPE WORK

GENERAL

This section covers the requirements for lubricant for the assembly of Ductile Iron pipes and specials suitable for Tyton push-on rubber ring joints.

SPECIFICATION

- a. The lubricant must have the following characteristics: must have a paste like consistency and be ready for use.
- b. must adhere to wet and dry surfaces of DI pipes and rubber rings.
- c. to be applied in hot and cold weather; ambient temperature 0 - 50°C, temperature of exposed pipes up to 70°C.
 - must be nontoxic.
 - must be water soluble.
 - must not affect the properties of the drinking water carried in the pipes.
 - must not have an objectionable odor.
 - must not be harmful to the skin.
 - must have a shelf live not less than 2 years.

ACCEPTANCE TEST

They shall be conducted in line with the provisions of the IS: 9523.

a. Jointing

- Jointing of DI pipes and fittings shall be done as per IS: 12288 and manufacturer's recommendations. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. Rubber sealing rings/ V gaskets used for jointing shall conform to IS: 638, IS: 12820 and IS: 5382.

b. Spigot and Socket Joints

- These shall have sockets which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS: 12820 and rubber rings shall be as per IS: 5382.
- In jointing DI pipes and fittings, the Contractor shall take into account the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, so that the rubber ring as per IS: 12820 and IS: 5382 is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier or as otherwise directed by the Engineer.

c. Gaskets for Flanges

- The gaskets used between flanges of pipes shall be of EPDM conforming to IS: 638 of thickness between 1.5 to 3 mm suitable for sewage conveyance.

d. Flanged Joints

- These shall comply with dimensions and drilling details in IS: 8329 for PN 20 flanges. All flanged joints between steel and ductile iron pipe work shall be electrically isolated joints. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All materials shall be supplied by a specialist manufacturer and be to the approval of the Engineer.
- Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The recommended bolting torque to be followed for

assembling flanges shall be as specified in manufacturer's instructions. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified. They shall be coated with coal tar epoxy coating after tightening.

e. Cement Mortar Lining

- All pipes and fittings shall be internally lined with cement mortar in accordance with ISO: 4179/ IS: 11906. Cement mortar lining shall be applied at the factory in conformance with the above-mentioned standards. No admixtures in the mortar shall be used without the approval of the Engineer.
- Pipe linings shall be inspected on site and any damage or defective areas shall be made good to the satisfaction of the Engineer. The Contractor may use specialist mortars, mortar additives or curing agents only with the approval of the Engineer.
- Lining shall be uniform in thickness all along the pipe. The minimum thickness of factory applied cement mortar lining shall be 3 mm for DN 300 mm pipe; 5 mm for DN 350 to 600 mm pipe; and 6mm for DN 800 mm pipes.

Certain sections are amplified as follows:

- No additives shall be used without the written approval of the Engineer and shall be used strictly in accordance with the manufacturer's recommendations.
- The minimum thickness of the lining at one point shall not be less than 4 mm.

f. Specials

- Standard DI fittings (Class K9) shall be in accordance with IS: 9523. Wherever standard DI specials are not available, they shall be manufactured and tested as per requirements with the approval of Engineer.

g. Coatings

General

- Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Buried pipes and fittings shall also have a site or factory applied polythene sleeving. Coating shall not be applied to pipe and fittings unless its surface is clean, dry and free from rust. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer.

h. Zinc Coating

- Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m² as described in Clause 5.2 of ISO 8179.

i. Bitumen Coating

- Bitumen coating shall be of normal thickness 75 microns unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS: 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions. Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

j. Pipe flow direction

- All pipes shall have flow direction and system types. This will be done by standard stencils, prepared with letter sizes as conveyed. Minimum letter height is 1-1/4 inches for ducts and 3/4 inch for pipes. Stencil Paint: Exterior, oil-based alkyd gloss black enamel, except as otherwise indicated. Paint may be in pressurized spray-can form.

k. Testing

- Tests on pipes and fittings shall be carried out in accordance with IS: 8329 and IS: 9523. The Engineer shall be permitted free access to the place of manufacture for the purpose of examining and witnessing the testing of pipes and fittings.

l. Failure to Pass the Test

- All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to be unsatisfactory in any way shall be redone by the Contractor.

5.14 CENTRIFUGALLY CAST IRON HUBLESS PIPES & FITTINGS AS PER IS 15905:2011 / ISO 6594

5.14.1 SCOPE

Centrifugally Cast Iron Hub less Pipes and Fittings as per IS 15905:2011 / ISO 6594 shall have the following properties

S.NO	PARAMETERS	DISCRIPTION
1	MATERIAL	CAST IRON - GRADE FG 150 MIN.
2	PRODUCT SPECIFICATION	IS 15905 / ISO 6594
3	USAGE	SOIL, WASTE, VENTILATION, AND RAINWATER
4	RANGE	DN 50mm, 75mm, 100mm, 150mm, 200mm, 250mm and 300mm
5	DENSITY OF MATERIALS	7.15 gm/cm ³
6	COEFFICIENT OF THERMAL EXPANSION	0.0105 mm/m°K
7	FIRE RESISTANCE (class) DIN 4102	Non-Combustible
8	TENSILE STRENGTH	150 N/mm ² (Min.)
9	HARDNESS	230 HBW (Max.)
10	COMPRESSIVE STRENGTH	600 N/mm ²
11	SHEAR STRENGTH	173 N/mm ²
12	POISSON'S RATIO	0.26
13	MODULUS OF ELASTICITY	10 x 10 ⁵ N/mm ²
14	SPECIFIC HEAT CAPACITY	265 J/kgK (20°C to 200°C)
15	THERMAL CONDUCTIVITY	52.5 W/mK (100°C)
16	HYDROSTATIC PRESSURE	0.7 Kg/cm ²
17	FLAMMABILITY	Does not promote fire
18	COATING	Epoxy Coating, both inside & outside surface of Pipes & Fittings
19	JOINTS	Stainless Steel Shielded Coupling with EPDM Rubber Gasket
20	PERFORMANCE REQUIREMENTS AT SITE	On site water test or smoke test to be done to check leak tightness of the system installed.

- a. Rectangular type with openable circular lid: As per DSR item no. 18.58.2
- b. 150mm nominal size square 100 mm diameter of the inner hinged round grating:
As per DSR item no. 18.58.2.1
- c. S&S centrifugally cast (spun) iron pipes (Class LA) conforming to IS - 1536 : As per DSR item no. 18.27

5.14.2 FITTINGS

Fittings shall be used for cast iron class (LA pipes shall conform to IS:1538-1976). Whenever possible junction from branch pipe shall be made by wyes. All cast iron water main pipes and fittings shall be manufactured to IS:1536 of tested quality. The pipes and fittings shall either be spigot and socket type or as called for. The pipes and fittings shall be of uniform material throughout and shall be free from all manufacturing defects.

5.14.3 TESTING

- a. Testing procedure specified below apply to pipes above ground including Hubless pipe laid in ceiling & inside shaft.
- b. Entire drainage system shall be tested for water tightness and smoke tightness during and after completion of the installation. No portion of the system shall remain untested. Contractor must have adequate number of expandable rubber bellow plugs, manometers, smoke testing machines, pipe and fitting work test benches and any other equipment necessary and required to conduct the tests.
- c. All materials obtained and used on site must have manufacturers hydraulic test certificate for each batch of materials used on the site.

5.14.4 RATES

- a. Rates quoted for all items quoted shall be inclusive of all work and items given in the specifications and Schedule of Quantities.
- b. Rates are applicable for the work in under the ground, floors, in shafts at ceiling level area for all depths and building up to 45m in height.
- c. Rates are inclusive of cutting holes and chases in masonry work and making good the same.
- d. Rates are inclusive of pre-testing and onsite testing of the installations, materials and commissioning of the works

5.15 CENTRIFUGAL /SPUN CAST IRON**5.15.1 CAST IRON PIPE (SOCKET & SPIGOT TYPE)**

Pipes shall be centrifugally cast (spun) iron soil pipes conforming to IS: 3989. All pipes shall be straight and smooth and their inside free from irregular bore, blow holes, crack sand other manufacturing defects. All drainage pipes shall be cast iron pipes. Pipe installation location shall be as per drawing.

5.15.2 JOINTING & FIXING

- a. All cast iron pipes and fittings shall be jointed with drip seal PJS-43 which shall be free from impurities. In wet trenches joints shall be made from lead wool. Nothing extra shall be paid for lead wool joints. Depth of drip seal and weight for joints shall be as per the relevant IS code or recommended by manufacturer, whichever is on higher side.
- b. The spigot of pipe or fittings shall be centered in the adjoining socket by caulking. Sufficient turns of tarred gaskin shall be given to leave unfilled the required depth of socket for depth of 45mm when the gaskin has been caulked tightly home. Joining ring shall be placed round the barrel and against the face of the socket. Drip seal shall then be applied to fill the remainder of the socket. This shall be done in one pouring.
- c. For lead wool joints the socket shall be caulked with tarred gaskin rope, as explained above. The lead wool shall be inserted into the sockets and tightly caulked home, skein by skein, with suitable tools and hammers of not less than 2 kg weight until joint is filled.
- d. Instead of drip seal joints, Rubber ring joints can also be provided. In case of CI pipes of spigot-socket with rubber ring joints as specified in BOQ, the rubber rings shall conform to IS-5382.
- e. Cast iron pipes under floor finish in sunken slabs and in wall chases (when cut specially for the pipe) shall be encased in cement concrete 1:2:4 mix (1 cement :2 coarse sand :4stone aggregate 12mm size) 75mm in bed and all around. When pipes are running well above the structural slab, the pipes shall be supported with suitable cement concrete supports, the details of which shall be as per drawing and required height at intervals of 1.8m. Rate for concrete all around pipes shall be inclusive of pillars, supports, shuttering and centering.

5.15.3 MEASURES TAKEN DURING INSTALLATION

- a. Cutting and Making Good Holes/ Chases
- b. Pipes shall be fixed and tested as the building work proceeds. Contractor shall provide all necessary holes, cut outs and chases in structural members as the building work proceeds. Wherever holes are cut or left originally, they shall be made good with cement concrete 1:1:2 (1 cement: 1coarse sand :2 stone aggregate 20mm nominal size) or cement mortar 1:2 (1 cement :2 coarse sand) as directed by the Engineer-in-Charge and the surface restored as in original condition to the entire satisfaction of the Engineer-in-Charge and no extra cost shall be charged.

5.15.4 Pipe Flow direction

All pipes shall have flow direction and system types. This will be done by standard stencils, prepared with letter sizes as conveyed. Minimum letter height is 1-1/4 inches for ducts and 3/4 inch for pipes. Stencil Paint: Exterior, oil-based alkyd gloss black enamel, except as otherwise indicated. Paint may be in pressurized spray-can form. Pipes shall be painted to standard colour code IS:2379:1990 as specified by the Engineer.

5.15.5 TESTING

- a. Testing shall be done in accordance with IS: 1172 and IS: 5329 except as may be modified herein under.
- b. Before use at site all CI pipes shall be tested by filling up with water for at least 30 minutes. After filling, pipes shall be struck with a hammer and inspected for blow holes and cracks. All defective pipes shall be rejected and removed from the site within 48 hours. Pipes with minor sweating may be accepted at the discretion of the Engineer-in-Charge.
- c. CI pipes shall be tested in sections after installation, by filling up the stack with water. All openings and connections shall be suitably plugged as approved by the Engineer-in-Charge. The total head in the stack shall be 4.5m at the highest point of the section under test. A tolerance of 2 litres/cm of diameter/ km of pipeline measured during the last ten minutes of the period of test shall be allowed. The period of test shall be as directed by the Engineer-in-Charge. If any leakage is visible, the defective part of the work shall be cut out and made good. A slight amount of sweating which is uniform may be allowed but excessive sweating from

a particular pipe or joint shall be watched and shall be construed to be a defect and shall be made good.

- d. The Contractor shall test all vent pipes by a smoke testing machine. Smoke shall be pumped into the stack after plugging all inlets and connections and filling water in all trap seals. The test shall be conducted under a pressure of 25mm of water and shall be maintained for 15 minutes. The stack shall then be observed for leakages and all defective pipes and fittings removed or repaired as directed by the Engineer-in-Charge.
- e. A test register shall be maintained and all entries signed and dated by Contractor and Engineer-in-Charge. A Performa of the proposed test register shall be submitted to the Engineer-in-Charge for approval.
- f. All pipes in wall chase or meant to be encased or buried shall be hydro tested before the chase is plastered or the pipe encased or buried

5.15.6 RATES

- a. Rates quoted for all items quoted shall be inclusive of all work and items given in the specifications and Schedule of Quantities.
- b. Rates are applicable for the work in under the ground, floors, in shafts at ceiling level area for all depths and building up to 45m in height.
- c. Rates are inclusive of cutting holes and chases in masonry work and making good the same.
- d. Rates are inclusive of pre-testing and onsite testing of the installations, materials and commissioning of the works

5.16 BRASS FLOAT VALVE:

5.16.1 SCOPE

Ball (Float) Valves: These valves are required to maintain a constant level in service reservoirs and steel storage tanks. These shall be available for static pressure of 7 Kg/cm² flanges faced and drilled to BS 10, table C, tested to 250 pounds per square inch. These shall conform to BS-1212 Part-2 and IS 1703.

5.16.2 FIXING

- a. The valves shall be fixed in position in the pipeline as shown in the drawing or as directed with necessary socket or union, nuts, flanges, hardware, gaskets, tail piece, etc.
- b. During installation, flow direction on the valve shall be checked.

5.16.3 TESTING

- a. The valves shall be body & seat tested at manufacturer's works as per the relevant standard & duly stamped. Test certificate shall be submitted for material & hydraulic testing.
- b. After fixing in the pipelines, the system shall be hydraulically tested for 1.5 times working pressure or 22.5 kg/cm² whichever is higher for minimum 4 hrs without any pressure drop. In case of leakage, contractor shall rectify/replace valves at his own cost

5.16.4 THE RATES ARE INCLUSIVE OF:

- a. Brass Float Valve of required type, size & pressure rating.
- b. Fixing & jointing material.
- c. Making all damage good to original condition after completion of installation work.
- d. Testing.
- e. All necessary materials, labour and use of tools.

5.17 FORGED BRASS BALL VALVES (For cold/Hot Water)**5.17.1 SCOPE**

The item includes provision of forged brass ball valves with hard chrome plated steel ball tested to a pressure not less than 15 kg/cm² with threaded or flanged joints including fixing and testing.

5.17.2 MATERIAL

- a. All ball valves shall be heavy duty of approved make.

- b. Valves shall have suitable for pressure of PN 15.
- c. Ball valves up to 80 mm shall have forged brass body, SS spindle & Teflon seat rings.
- d. Ball valve shall conform to IS: 9890 or BS: 1868.
- e. Full way lever operated forged brass ball of brass body with forged brass hard chrome plated steel ball tested to a pressure not less than 15 kg/cm² with threaded or flanged joints. The weight of the full way valve shall be as per the table given below with a tolerance of 5 percent. For Hot water the same shall be suitable for temperature upto 85° C.

Diameter in mm	Flanged arch (Kg)	Screwed arch (Kg)
15	1.021	0.567
20	1.503	0.680
25	2.495	1.077
32	3.232	1.559
40	4.082	2.268
50	6.691	3.232
65	10.149	6.804
80	13.381	8.845

- f. The valves shall have either screwed ends or flanged ends.

5.17.3 FIXING

- a. The valves shall be fixed in position in the pipeline as shown in the drawing or as directed with necessary socket or union, nuts, flanges, hardware, gaskets, tail piece, etc.
- b. During installation, flow direction on the valve shall be checked.
- c. Valves shall be preferably installed in horizontal position with adequate supports.

5.17.4 TESTING

- a. The valves shall be body & seat tested at manufacturer's works as per the relevant

standard & duly stamped. Test certificate shall be submitted for material & hydraulic testing.

- b. After fixing in the pipelines, the system shall be hydraulically tested for 1.5 times working pressure or 22.5 kg/cm² whichever is higher for minimum 4 hrs without any pressure drop. In case of leakage, contractor shall rectify/replace valves at his own cost
- c. Valves shall also be tested for its hand wheel / lever function by frequent on-off operation.

5.17.5 THE RATES ARE INCLUSIVE OF:

- a. Forged brass Ball Valve of required type, size & pressure rating.
- b. Fixing & jointing material.
- c. Making all damage good to original condition after completion of installation work.
- d. Testing.
- e. All necessary materials, labour and use of tools.

5.18 C.I. BUTTERFLY VALVE (FOR COLD)

5.18.1 SCOPE

The item includes provision of Cast Iron Butterfly valves with integrally moulded liner of nitrile or EPDM, Stainless-steel disc and wheel / lever operated handle with threaded or flanged joints including fixing and testing.

5.18.2 MATERIAL

- a. All butterfly valves shall be heavy duty cast iron of approved make.
- b. Valve shall be either wafer type design or flanged ends.
- c. Valve shall have manual handle / lever operation.
- d. C.I. butterfly valves water end type class PN 16 as per I.S:13095 or BS:5155 with integrally moulded liner of nitrile or EPDM, SS Disc and wheel / lever operated. For Hot water the same shall be suitable for temperature upto 85° C.

5.18.3 FIXING

- a. The valves shall be fixed in position in the pipeline as shown in the drawing or as directed with necessary socket or union, nuts, flanges, hardware, gaskets, tail piece, etc.
- b. During installation, flow direction on the valve shall be checked.
- c. Valves shall be installed in horizontal / vertical position with adequate supports.

5.18.4 TESTING

- a. The valves shall be body & seat tested at manufacturer's works as per the relevant standard & duly stamped. Test certificate shall be submitted for material & hydraulic testing.
- b. After fixing in the pipelines, the system shall be hydraulically tested for 1.5 times working pressure for minimum 4 hrs without any pressure drop. In case of leakage, contractor shall rectify/replace valves at his own cost
- c. Valves shall also be tested for its hand wheel / lever function by frequent on-off operation.

5.18.5 THE RATES ARE INCLUSIVE OF:

- a. Cast Iron Butterfly Valve of required type, size & pressure rating.
- b. Fixing & jointing material.
- c. Making all damage good to original condition after completion of installation work.
- d. Testing.
- e. All necessary materials, labour and use of tools.

5.19 NON-RETURN VALVE:**5.19.1 SCOPE**

Where specified non-return valve shall be provided through which flow can occur in one direction only. It shall be single door swing check type of best quality conforming to IS: 778. For Hot water the same shall be suitable for temperature upto 85° C

5.19.2 FIXING

- a. The valves shall be fixed in position in the pipeline as shown in the drawing or as directed with necessary socket or union, nuts, flanges, hardware, gaskets, tail piece, etc.
- b. During installation, flow direction on the valve shall be checked.

5.19.3 TESTING

- a. The valves shall be body & seat tested at manufacturer's works as per the relevant standard & duly stamped. Test certificate shall be submitted for material & hydraulic testing.
- b. After fixing in the pipelines, the system shall be hydraulically tested for 1.5 times working pressure or 22.5 kg/cm² whichever is higher for minimum 4 hrs without any pressure drop. In case of leakage, contractor shall rectify/replace valves at his own cost

5.19.4 THE RATES ARE INCLUSIVE OF:

- a. Non-Return Valve of required type, size & pressure rating.
- b. Fixing & jointing material.
- c. Making all damage good to original condition after completion of installation work.
- d. Testing.
- e. All necessary materials, labour and use of tools.

5.20 SLUICE VALVE:**5.20.1 SCOPE**

Sluice valves, where specified shall be flanged sluice valves of cast iron body. The spindle, valve seat and wedge nuts shall be gunmetal. They shall generally have non-rising spindle and shall be of the particular duty and design as specified. The valves shall be supplied with suitable flanges, non-corrosive bolts and asbestos fibre gaskets. Sluice valves shall conform to Indian standard IS: 780 and IS: 2906

5.20.2 MATERIAL

- a. All Sluice valves shall be heavy duty cast iron of approved make.
- b. Valve shall have circular handle operation.
- c. C.I. Sluice valves water end type class PN 16 as per IS: 780 and IS: 2906.

5.20.3 FIXING

- a. The valves shall be fixed in position in the pipeline as shown in the drawing or as directed with necessary socket or union, nuts, flanges, hardware, gaskets, tail piece, etc.
- b. During installation, flow direction on the valve shall be checked.
- c. Valves shall be installed in horizontal / vertical position with adequate supports.

5.20.4 TESTING

- a. The valves shall be body & seat tested at manufacturer's works as per the relevant standard & duly stamped. Test certificate shall be submitted for material & hydraulic testing.
- b. After fixing in the pipelines, the system shall be hydraulically tested for 1.5 times working pressure for minimum 4 hrs without any pressure drop. In case of leakage, contractor shall rectify/replace valves at his own cost
- c. Valves shall also be tested for its hand wheel / lever function by frequent on-off operation.

5.20.5 THE RATES ARE INCLUSIVE OF:

- a. Cast Iron Sluice Valve of required type, size & pressure rating.
- b. Fixing & jointing material.
- c. Making all damage good to original condition after completion of installation work.
- d. Testing.
- e. All necessary materials, labour and use of tools.

5.21 AIR RELEASE VALVE:**5.21.1 SCOPE**

The item includes supplying of single, double action or kinetic air Valve of specified diameter as mentioned in the schedule including fixing.

5.21.2 MATERIAL

- a. Single air valve shall have single small or large orifice for releasing air during pipe filling and ventilating the pipe during emptying. Air valves up to 50 mm diameter directly shall be screwed on the main.
- b. Double air valve shall have two ball chambers, on outlet of large capacity shall be provided for admission and release of bulk volume of air during emptying and filling of the main, another of small outlet type for the escape of smaller quantities of air accumulating under pressure. They shall be of flanged type.
- c. Air valve body, bonnet, glands, caps, joints support rings shall be best grey iron of selected grade, 200 of IS-210-1978 specification for grey iron castings.
- d. Ball guides of small orifice units and outlet bushes of large orifice valves shall be of gunmetal.
- e. Nipples, spindles shall be machined from rolled, extruded or forged high tensile brass or aluminium bronze.
- f. The balls shall be of rubber covered and vulcanite covered. The rubber shall have a smooth and solid surface. It shall be as per I.S. 638-1965 specification for rubber and insertion jointing.
- g. Air valve shall be provided with isolation valve with IS certification mark and isolation valve.

5.21.3 FIXING

The Air Valve shall be fixed in position as indicated in the drawing or as directed. They shall be fitted by means of flange joints or screwed joints to the pipeline.

5.21.4 TESTING

The Air Valve and the joints shall be tested hydraulically to a minimum pressure of 16 kg/cm² or 1.5 times working pressure whichever is greater for minimum 4hrs without any leakage.

5.21.5 RATES

- a. Supplying and fixing Air Valve of specified diameter and type with isolation valve.
- b. Fixing & Jointing material & specials.
- c. Painting.
- d. Making all damage good to original condition after completion of installation work.
- e. Testing & commissioning
- f. All necessary materials, labour and use of tools.

5.22 PRESSURE REDUCING VALVE:**5.22.1 SCOPE**

The item includes provision of pressure reducing valve of specified diameter with all accessories as mentioned in the schedule including fixing.

5.22.2 MATERIAL

- a. Pressure reducing valve is a device with suitable means of connection for insertion in a vertical pipeline for controlling the water pressure.
- b. Each pressure reducing valve (PRV) set/assembly shall be installed with pressure reducing/regulating valve, isolating valves & pressure gauges on inlet & outlet, strainer at inlet & pressure relief valve on outlet as called in BOQ.
- c. PRV shall be of brass housing, spring bonnet with adjustable opening having adjustable knob for pressure adjustment. Valve shall be vertical flow type, conforming to IS: 9739-1981.
- d. Each PRV shall contain loading neoprene diaphragm & a full floating, self-aligning, ignition resistant seat. Valve shall be of single stage pressure reduction type. Strainer provided at the inlet shall be of replaceable porous sintered metal type.

- e. Each pressure relief valve shall be of the fully enclosed type and fitted with hand easing gear. Each pressure relief valve in a pressure reducing station shall have a flow capacity equal to that of the pressure reducing valve. Pressure relief valves in locations other than reducing stations shall have flow capacities equal to that of the associated equipment.

5.22.3 FIXING

- a. The valve shall be fixed in position on the pipeline as shown in the drawing or as directed. The screwed or flanged joint shall be made to obtain complete watertight joint.
- b. The force of the diaphragm shall operate against the force of an adjustable spring. The inlet pressure shall have no influence in either the opening or closing the valve, hence, the outlet pressure shall remain constant always.
- c. Adjustment of Pressure:
The knob fitted on top of the PRV shall be turned toward (-) or (+) sign to reduce/increase the outlet pressure as desired range.

Inlet pressure	:	Max 5 bar
Outlet pressure	:	1.5 to 3.0 bar adjustable
Maximum pressure drop	:	3 bar

- d. Valves shall be either screwed ends or flanged ends with all required jointing/fixing accessories like tail piece, hardware, Teflon tape, gaskets, etc.

5.22.4 TESTING

The joints shall be tested to a hydraulic pressure of 1MPa (10 kg/cm²) or 1.5 times working pressure whichever is higher along with testing of pipeline for a minimum duration of 2 hrs.

5.22.5 RATES

- a. Pressure reducing valve set/assembly having pressure reducing valves of specified diameter, isolating valves & pressure gauges on inlet & outlet, strainer at inlet & pressure relief valve on outlet including fixing.
- b. Fixing & jointing material.

- c. Painting.
- d. Making all damage good to original condition after completion of installation work.
- e. Testing & commissioning.
- f. All necessary materials, labour and use of tools.

5.23 WATER METERS

- a. Water meter shall be BMS compatible with RS 485 port. Water meters of approved make and design shall be supplied for installation at locations as shown. The water meters shall meet with the approval of local supply authorities. Suitable valves and chambers or wall meter box to house the meters shall also be provided along with the meters.
- b. The meters shall conform to Indian Standard IS: 779 and IS: 2373. Calibration certificate shall be obtained and submitted for each water meter.
- c. Provision shall also be made to lock the water meter. The provision shall be such that the lock is conveniently operated from the top. Where the provision is designed for use in conjunction with padlocks, the hole provided for padlocks shall be a diameter not less than 4mm.
- d. (Note: The water meters to be installed and at every use of water such as Landscape irrigation, Domestic, Drinking Flushing, Rain water, HVAC soft etc.)

5.23.1 INSTALLATION OF WATER METERS

The G.I. lines shall be cut to the required lengths at the position where the meter and stop cock are required to be fixed. Suitable fittings shall be attached to the pipes. The meter and stop cock shall be fixed in a position by means of connecting pipes, jam nut and socket etc. The stop cock shall be fixed near the inlet of the water meter. The paper disc inserted in the ripples of the meter shall be removed. And the meter installed exactly horizontal or vertical in the flow line in the direction shown by the arrow cast on the body of the meter. Care shall be taken that the factory seal of the meter is not disturbed. Wherever the meter shall be fixed to a newly fitted pipeline, the pipeline shall have to be completely washed before fitting the meter.

5.23.2 TESTING

- a. All pipes, fittings and valves shall be tested in accordance with IS: 2065 except as may be modified herein under. All pipes, fittings and valves, after fixing at site, shall be tested to a hydrostatic pressure of 1.5 times the shut off head of the pump.
- b. The test pressure shall be maintained for a period of at least thirty minutes without any drop in pressure.
- c. A test register shall be maintained and all entries shall be signed and dated by Contractor(s) and the Engineer.
- d. For water meter size contractor to refer drawings.

5.23.3 RATES

- a. Water meter with electronic sensor.
- b. Electronic Sensor with BAS connectivity.
- c. Making flanged joints with nuts & bolts.
- d. Making all damage good to original condition after completion of installation work.
- e. Testing the entire system and rectification of defects if any.
- f. All necessary materials, labour and use of tools.

5.24 WATER TANK MANHOLE COVER:**5.24.1 SCOPE**

Water Tank cover shall be Ductile Iron Medium Duty as per EN 124.

5.24.2 TESTING

Water tank cover shall be tested as per specified load.

5.24.3 RATES

- a. Water tank/sump cover
- b. fixing & jointing with Concrete

- c. Making all damage good to original condition after completion of installation work.
- d. Testing the entire system and rectification of defects if any.
- e. All necessary materials, labour and use of tools.

5.25 EXPANSION JOINTS: -

5.25.1 SCOPE

Rubber expansion joints provide a proven and flexible solution to accommodate many types of movements and requirements of equipment.

These include:

- a. Accommodating for pressure loads
- b. Neutralizing axial, lateral and angular stress
- c. Reducing noise
- d. Isolating sources of vibration
- e. Prolonging the life of motive equipment
- f. They are used in all systems transporting fluids, slurries or gases under pressure, at ambient pressure or under vacuum over a wide range of temperatures.
- g. Low spring rates.
- h. Greater movement per arch.
- i. Manufactured in single or multiple arches.
- j. Choice of eight liner elastomer
- k. Choice of cover to match liner materials or different materials for better resistance to external conditions.
- l. Filled or unfilled arches.
- m. Galvanized carbon steel or stainless-steel split backup rings.
- n. Can be built with permanent offset to compensate for existing or designed piping misalignment.

5.26 Y STRAINERS**5.26.1 SCOPE**

- a. “Y” strainers shall be of C.I /Gun metal body and of suitable class as indicated in drawings & schematics or higher as required.
- b. Strainers shall incorporate removable stainless-steel screen with 3.175 mm (1/8”) perforations and permanent magnet.
- c. Strainers shall be provided with flanges at both inlet and outlet.
- d. Strainers shall be designed to enable blowing out of accumulated dirt and replacement of the screen without disconnection of the main pipe.
- e. Strainers shall be provided with equal size isolating butterfly valves of approved brands as shown in drawings so that the strainer may be cleaned without draining the system.

5.26.2 FIXING

- a. The Strainer shall be fixed in position in the pipeline as shown in the drawing or as directed with necessary socket or union, nuts, flanges, hardware, gaskets, tail piece, etc.
- b. During installation, flow direction on the strainer shall be checked.
- c. strainer shall be preferably installed in horizontal position with adequate supports.

5.26.3 TESTING

- a. The strainer shall be body & seat tested at manufacturer's works as per the relevant standard & duly stamped. Test certificate shall be submitted for material & hydraulic testing.
- b. After fixing in the pipelines, the system shall be hydraulically tested for 1.5 times working pressure or 22.5 kg/cm² whichever is higher for minimum 4 hrs without any pressure drop. In case of leakage, contractor shall rectify/replace valves at his own cost

5.26.4 THE RATES ARE INCLUSIVE OF:

- a. Strainer of required type, size & pressure rating.
- b. Fixing & jointing material.
- c. Making all damage good to original condition after completion of installation work.
- d. Testing.
- e. All necessary materials, labour and use of tools.

5.27 PRESSURE GAUGE**5.27.1 SCOPE**

- a. Pressure gauge shall be provided as shown in drawings. Pressure gauge shall be 100 mm dia gunmetal bourdon type with gunmetal isolation ball valve, tapping and connecting pipe and nipple. The gauge shall be installed at appropriate height for easy readability.
- b. Pressure gauges fitted in the installations shall comply with IS 4224. The scale subdivision shall not exceed
- c. 0.2 bar for a maximum scale value up to and including 20 bars
- d. 0.5 bar for a maximum scale value of more than 20 bar
- e. 1.0 bar for a maximum scale value more than 20 bar.

5.27.2 FIXING

- a. The pressure gauge shall be fixed in position in the pipeline as shown in the drawing or as directed with necessary socket or union, nuts, flanges, hardware, gaskets, tail piece, etc.
- b. During installation, flow direction on the strainer shall be checked.
- c. pressure gauge shall be preferably installed in vertical position with adequate supports.

5.27.3 TESTING

- a. The pressure gauge shall be tested at manufacturer's works as per the relevant

standard & duly stamped. Test certificate shall be submitted for material & hydraulic testing.

- b. After fixing in the pipelines, the system shall be hydraulically tested for 1.5 times working pressure or 22.5 kg/cm² whichever is higher

5.27.4 THE RATES ARE INCLUSIVE OF:

- a. pressure gauge of required type, size & pressure rating.
- b. Fixing & jointing material.
- c. Making all damage good to original condition after completion of installation work.
- d. Testing.
- e. All necessary materials, labour and use of tools.

6.0 DRAINAGE**6.1 SCOPE OF WORK**

Work under this section consists of furnishing all labour, materials equipment and appliances necessary and required to completely install for Drainage system (Sewage & Storm water) as required by the drawings, specified hereinafter and given in the Schedule of Quantities.

Without restricting to the generality of the foregoing, the drainage system shall include the following: -

- a. All soil/ wastewater & rainwater lines to various parts of the building including connection to vertical stack & to final disposal point which maybe city sewer / storm manhole / Sewage Treatment Plant.
- b. Pipe slopes/ gradient to achieve self-cleansing velocity.
- c. Drain Connections to all plumbing fixtures, Floor drains, kitchen/laundry equipment, tanks, appliances, irrigation features, water bodies.
- d. Supports/ Clamps, Excavation& refilling of pipe trenches, required civil work.

6.2 GENERAL REQUIREMENTS

- a. All material shall be new & quality conforming to specifications & subject to the approval of Engineer.
- b. All material shall be rust proof. The material in direct/ indirect contact shall compatible to prevent electrolytic/chemical (bimetallic) corrosion.
- c. Drainage lines shall be truly vertical, horizontal or in slopes in a neat workmanship like manner.
- d. Pipe shall be securely fixed to the wall or ceiling by providing clamps at regular intervals.
- e. Access doors & clean out plugs shall be provided at regular intervals as per code & plumbing good practices unless otherwise shown in the drawing.
- f. Access door & clean out plugs shall be so located that, they can be easily accessible for maintenance.

- g. All drainage work shall be done in accordance with local municipal/authority bye laws.
- h. Location of manholes catch pts shall be got approved from Engineer before execution.
- i. The contractor shall install a drainage system to efficiently collect; drain & dispose all soil & waste water from various parts of building, appurtenances & equipment. The piping shall finally terminate & discharge into final disposal point which may be municipal (or any other authority's) sewer manhole, STP or any other disposal point as shown/indicated in drawing. The system shall also include rain/storm water collection from various parts of buildings as well as from the ground surface, roads, open areas, etc. The piping shall finally terminate & discharge into final disposal point which may be municipal (or any other authority's) drain, percolation/recharging wells or any other disposal point as indicated in the drawing.
- j. All drainage piping shall be installed at depth greater than 80 cm below finished ground level.
- k. All sewage piping network shall include gully tarps, inspection & manhole chambers, drop manholes, intercepting chambers, etc. All storms piping network shall include gully tarps, catch pits, de silting chambers, etc. Storm network shall be either through piping or channel with openable gratings.
- l. All sewage piping network shall be vented at start of all branching drains, main drain, lowest & highest points & at interval as indicated in the drawing. All venting arrangements shall be concealed & unconstructive. Work shall be strictly in accordance with IS: 1742.
- m. Wherever the drainage piping run above water supply pipes, it shall be encased completely in cement concrete 1:2:4 all round with prior approval from Engineer.
- n. All drainage piping shall be subject to hydraulic test & smoke test for its soundness. A test register shall be maintained at site & all performance test data shall be recorded & duly signed by contractor & Engineer.

6.3 UPVC PIPE**6.3.1 uPVC SWR**

uPVC Soil, Waste, RWP & Vent system conforming to IS : 13592 - Type B, uPVC Class-3 & Class-4 as per IS 4985 comprising uPVC pipes and uPVC fittings IS 14735 (moulded as well as fabricated) like bends, tees, Y-tees, crosses, boss connections, access pieces, saddle pieces, cleanouts, adaptors for connections to other materials, plugs, reducers, cowls, offsets and other specials. Jointing shall be done with push fit rubber ring jointing technique in general. Solvent cement joints may be provided for fittings and specials which are not manufactured with push fit rubber joints. Pipes may be laid/ fixed in pipe ducts, sunken floors, under slung from ceiling. The pipes laid in sunken floor shall be encased with 75 mm thick cement concrete (1:2:4) all around. Pipes fixed on MS structural supports shall be fixed with U-clamps made from 10 mm dia MS bar complete with necessary threading nuts and washers (MS Structural Work to be included in the rate). The installation shall be complete in all respects including cutting chases / holes in walls, slabs and making good the same as per specifications. Providing GI pipe sleeves of suitable higher size wherever pipes crossing a fire rated wall / floor slab and sealing of space around pipe and pipe sleeve with glass wool in between and fireproof sealant at either end to the satisfaction of the PMC/Employer and making good the same after pipes have been duly laid and testing. Seal ring fittings shall be used where necessary to accommodate thermal movement. The rubber seals for seal ring joints shall be of section that gives more than one point of contact with the pipe and shall be to the material requirements of BS 7874, BS EN 681-1, BS EN 681-2. Horizontal and vertical pipe work shall include allowance for thermal expansion in accordance with the manufacturer's recommendations. All expansion units shall be anchored. Access shall be provided by means of an integrally moulded door in an access fitting with an externally fitted rubber seal and secured with two galvanised bolts and nuts, or alternatively by a two-piece clamp type door fitted into the pipe run. Access shall be installed on all vertical foul drainage pipes at the specified height above each finished floor level, to centre line of the access door and horizontally in accordance with the Building Regulations and BS EN 12056-2.

6.3.2 UPVC PIPES (INTERNAL TOILET)

Providing & fixing uPVC soil and waste pipe work comprising uPVC pipe conforming to IS :4985-2000 up to pipe sizes 65 mm and IS : 13592 - Type B for sizes above 65 mm of required class as specified including fittings (moulded as well as fabricated) like elbows, bends, reducers, threaded tail pieces, caps and other specials. Chasing,

cutting and making good the walls, complete in all respects including testing of complete installation. All under slung soil pipes to be low noise PP Pipes (Silent polypropylene). Pipes may be laid/ fixed in sunken floors, under slung from ceiling. The pipes laid in sunken floor shall be encased with 75 mm thick cement concrete (1:2:4) all around. Pipes fixed on MS structural supports shall be fixed with U-clamps made from 10 mm dia MS bar complete with necessary threading nuts and washers (MS Structural Work to be included in the rate). The installation shall be complete in all respects including cutting chases / holes in walls, slabs and making good the same as per specifications. Providing GI pipe sleeves of suitable higher size wherever pipes crossing a fire rated wall / floor slab and sealing of space around pipe and pipe sleeve with glass wool in between and fire proof sealant at either end to the satisfaction of the PMC/ Employer and making good the same after pipes have been duly laid and testing.

6.3.3 uPVC PIPES AND FITTINGS

The pipes shall be round and shall be supplied in straight lengths with socketed ends. The internal and external surfaces of pipes shall be smooth, clean, and free from grooving and other defects. The ends shall be cleanly cut and square with the axis of the pipe. The pipes shall be designed by external diameter. Fittings shall be of the same make as that of pipes, injection moulded and shall conform to Indian Standard.

6.3.4 LAYING, JOINTING

The pipes shall be laid in uniform slope and proper levels. All vertical pipes shall be truly vertical fixed by means of stout clamps in two sections, bolted together, built into the walls, wedged and neatly jointed. The branch pipes shall be connected to the stack at the same angle as that of fittings. All connections between soil, waste and ventilating pipes and branch pipes shall be made by using pipe fittings with inspection doors for cleaning. Pipes shall be fixed in a manner as to provide easy accessibility for repair and maintenance and shall not cause obstruction in shafts. Where the horizontal run off the pipe is long or where the pipes cross over building expansion joints etc. suitable allowance shall be provided for any movements in the pipes by means of expansion joint etc. such that any such movement does not damage the installation in any way.

Provision shall be made for the effect of thermal movement by not gripping or disturbing the pipe at supports between the anchors for suspended pipes. The supports shall allow the repeated movements to take place without abrasion.

Jointing for uPVC pipes shall be made by means of solvent cement for horizontal lines and 'O' rubber ring for vertical line. The type of joint shall be used as per site conditions / direction of the PMC/Employer's site representative. Where uPVC pipes are to be used for rainwater pipes, the pipe shall be finished with GI adopter for insertion in the RCC slab for a water proof joint complete as directed by PMC/Employer's site representative.

uPVC pipes require supports at close intervals. Recommended support spacing for unplasticised PVC pipes is 1400 mm for pipes 50 mm dia and above. Pipes shall be aligned properly before fixing them on the wooden plugs with G.I clamps. Even if the wooden plugs are fixed using a plumb line, pipe shall also be checked for its alignment before clamping, piping shall be properly supported on, or suspended from clamps, hangers as specified and as required. The Contractor shall adequately design all the brackets, saddles, anchors, clamps and hangers and be responsible for their structural sufficiency. Pipe supports shall be primer coated with rust preventive paint.

6.3.5 REPAIRS

While temporary or emergency repairs may be made to the damaged pipes, permanent repairs shall be made by replacement of the damaged section. If any split or chip out occur in the wall of the pipe, a short piece of pipe of sufficient length to cover the damaged portion of the pipe is cut. The sleeve is cut longitudinally and heated sufficiently to soften it so that it may be slipped over the damaged hard pipe.

6.4 GALVANISED IRON PIPES & FITTINGS

- a. The pipes shall be galvanized mild steel welded (ERW) or (HFW) screwed and socketed conforming to the requirements of IS:1239 of heavy class (C) and Medium class (B).
- b. The pipes under this standard are designated by their nominal bore and are further classified as Light, Medium and Heavy depending upon their wall thickness and shall be used as per required suitable pressure. Sockets of these pipes are designated by respective nominal bore of the pipe.

6.4.1 JOINTS:

The threads of all screwed and socket pipes shall conform to IS-554. The minimum length of thread in 'Light' pipe shall be 80 percent of specified in IS-554. Each tube shall be supplied with one socket.

6.4.2 LENGTH:

The tubes shall be supplied in random lengths of 3 to 6 m.

6.4.3 GALVANIZING:

When tubes are required to be galvanized, the Zinc coating shall conform to IS 4736. (Hot dip zinc coatings on steel tubes).

6.4.4 MANUFACTURING PROCESS:

Tubes are made from tested quality of steel manufactured by any approved process Electric Resistance Welded (ERW),

- a. The Galvanizing shall conform to IS:4736, the hot dip zinc coating shall be uniform, adherent reasonably smooth and free from such imperfections as flux, ash and drop inclusions, bare patches, black spots, pimples, lumpiness, runs, rust strains, bulky white deposits and blisters. The pipes and sockets shall be cleanly finished, well galvanized in and out and free from cracks, surface flaws laminations and other defects. All screw threads shall be clean and well cut. The ends shall be cut cleanly and square with the axis of the pipe.
- b. The fittings shall be malleable iron and comply with all the requirements of the pipes. The sizes of pipes and fitting is specified in the schedule of quantities.
- c. Hydraulic test: Each pipe shall be hydraulically tested at manufacturer's work to withstand a test of Pressure of 5 Mpa.
- d. Marking: The different classes of pipes shall have 75mm colour bands when arrived on site.
- e. The following colour bands shall be provided.

Light	-----	Yellow
Medium	-----	Blue
Heavy	-----	Red

- f. Fittings: The fittings shall be malleable iron screwed fittings and shall conform to IS:1879. The fittings are classified as Light, Medium and Heavy. The sizes of pipes and fitting is specified in the schedule of quantities.

6.4.5 HYDRAULIC TEST:

Each tube shall be hydraulically tested at manufacturer's works to withstand a test pressure of 5 Mpa.

6.4.6 MARKING:

The different classes of tubes shall have 75 mm colour bands before leaving the manufacture's works.

Light tube Yellow

Medium tube Blue

Heavy tube Red

Table Dimensions and Nominal Weight of Black Steel Tubes (HEAVY) (IS 1239)

15	21.8	21.0	3.25	1.45	1.46	1.51	1.52
20	27.3	26.5	3.25	1.90	1.91	1.98	1.99
25	34.2	33.3	4.05	2.97	2.99	3.07	3.09
32	42.9	42.0	4.05	3.84	3.87	3.96	3.99
40	48.8	47.9	4.05	4.43	4.47	4.59	4.63
50	60.8	59.7	4.50	6.17	6.26	6.35	6.42
65	76.6	75.3	4.50	7.90	8.02	8.11	8.23
80	89.9	88.0	4.85	10.10	10.30	10.34	10.51
100	115.0	113.10	5.4	14.4	14.7	14.72	15.02
125	140.8	138.50	5.4	17.8	18.3	18.19	18.69
150	166.5	163.9	5.4	21.2	21.8	21.67	22.27

6.4.7 Permissible Working Pressure for Mild Steel Tubes

N.B. of pipe mm	Working Pressure					
	Light		Medium		Heavy	
	lbs/sq.in	Kg.cm ²	lbs/sq.in	Kg.cm ²	Lbs/sq.in	Kg.cm ²
15	150	10.55	300	21.09	350	24.61
20	150	10.55	300	21.09	350	24.61
25	150	10.55	300	21.09	350	24.61
32	125	8.80	250	17.58	300	21.09
40	125	8.80	250	17.58	300	21.09
50	100	7.03	200	14.06	250	17.58

65	100	7.03	200	14.06	250	17.58
80	100	7.03	200	14.06	250	17.58
100	100	7.03	171	12.02	228	16.03
125	-	-	171	12.02	213	14.79
150	-	-	142	9.98	171	12.02

6.4.8 MECHANICAL COUPLING / ADAPTOR

Mechanical coupling is required for pipe jointing. Coupling is required at location where two different type of pipe material connection is required.

6.4.9 PAINTING

All pipes above ground shall be painted with one coat of red oxide and two coats of synthetic enamel paint of approved shade and quality. Pipes shall be painted to standard colour code IS:2379:1990 as specified by the Engineer

6.4.10 TESTING

- a. The openings of the pipes shall be sealed for the section to be tested. All control valves shall be positioned open for the duration of the test and open end closed with water tight fittings. The testing pressure on completion of the work shall not be less than 1.5 times the working pressure of the pipes or 7.5 Kg/Sq.cm whichever more is.
- b. Pressure shall be applied either by hand pump or power-driven pump. Pressure gauges shall be calibrated, correctly positioned and closely observed to ensure that at no time are the test pressure exceeded. The systems shall be slowly and carefully filled with water to avoid surge pressure or water hammer. Air vents shall be open at all high points so that air may be expelled from the system during filling.
- c. When the system has been fully charged with water and air displaced from the line air vent shall be closed and the line initially inspected for seepage at joints and firmness of supports under load. Pressure is reached. Without any additional requirement of make-up-water the test pressure should not fall more than 0.02 MPa (0.2 kg. /sq.cm) at the end of one-hour test duration.
- d. The water pressure shall be maintained for minimum of two hour with accurate pressure gauge. The engineer shall examine carefully all the joints for leakage. Any joint found leaking shall be redone, and all leaking pipes removed and replaced without extra cost.

6.4.11 RATES

- a. G.I. Pipes and fittings of specified diameter & pressure class.
- b. Laying and cutting the pipe wherever necessary and wastage.
- c. Underground installation with all necessary civil work if specified in bill of quantities like excavation, dewatering, backfilling, bedding, encasing, etc.
- d. Or over ground installation with supports/clamps, accessories required.
- e. Pipe & Fitting with insulation for hot water application if specified in schedule of quantities
- f. Jointing & fixing material.
- g. Making all damage good to original condition after completion of installation work.
- h. Testing the entire system and rectification of defects if any.
- i. Painting the pipe line for over ground installation & pipe protection with coating & wrapping coating if mentioned in schedule of quantities.
- j. All necessary materials, labour and use of tools.

6.5 CLEAN OUT PLUG**6.5.1 SCOPE**

The scope includes providing and fixing UPVC clean out plugs in drainage systems as per the direction of PMC/Employer. GI flanged type of round shape matching pipe size as approved by PMC/Employer and shown in the drawing. Ceiling cleanout assembly shall be threaded with key hole for opening/ flanged type suitable for pipe. Threaded cover shall be used up to 100 mm size or as per site requirement and above shall be GI flanged type with GI nuts and bolts., whereas nickel bronze and GI flanged type cover shall be used for CI/ CI LA pipe work.

6.5.2 MATERIAL

- a. The purpose of a clean out plug is to provide an access to the buried / exposed drainage system for cleaning out the clogged materials within the drain pipes.
- b. It is a one-way access to the drain pipe system and is usually installed at the upper

end of the drain pipe system, so as to be able to make use of gravity flow in case required.

- c. The cover of the clean out plug may be made of Stainless Steel or Brass.

6.5.3 INSTALLATION.

- a. The plugs shall be installed in accordance with the requirements and the manufacturer's installation instructions.
- b. The clean out plugs shall be installed after the testing of the drainage stacks are completed and approved by the Engineer.
- c. The clean out plugs shall be installed in the floor as directed by the Engineer.
- d. Each clean out plug shall have a complete screw down cover such that there is no leakage of bad odour through.

6.5.4 RATES:

- a. The rates are for each Clean out plug installed.
- b. Rates quoted for all items quoted shall be inclusive of all work and items given in the specifications and Schedule of Quantities.
- c. Rates are inclusive of cutting holes in flooring and making good the same with appropriate and durable silicon sealant.
- d. Rates are inclusive of pre-testing and onsite testing of the installations, materials and commissioning of the works.

6.6 PREFABRICATED GREASE INTERSEPTER: -

6.6.1 SCOPE

Prefabricated Grease separator shall be of HDPE / Polyethylene conforming to EN 1825 / DIN 4040 / 100 suitable for underground/above ground installation with integrated sludge trap, sloped interior base improves cleaning and reduces disposal time, inlet flow calming system and outlet flow regulation device, inlet and outlet interchangeable, slanted twin access covers with quick release odour tight snap closures, inspection window with interior cleaning arm. The contractor shall refer drawings for selection.

Grease separator shall have mix & pump version manually controlled odour free disposal, cleaning and refilling system at touch of button, maintenance free pump for separator cleaning and disposal, includes closure valve for easy pump removal, pump floor mount included with installation hardware and anti-vibration matt, manual hand valve for transfer from cleaning to disposal mode, of adequate pumping capacity, with necessary cabling, top mounted water jet(s) for grease layer breakup and water spray nozzles for interior wall cleaning during disposal, manual hand valve for water refill with interior threaded refill inlet with air gap as per manufacturer specification.

6.7 LIFTING STATION FOR PREFABRICATED GREASE SEPARATOR

6.8.1 SCOPE

Pressure sensor controlled single or twin wastewater pumps with multi-vane impeller to pump wastewater with or without sewage (open channel passage 40 mm). Pump shall be rated submersible (IP 68) with necessary cabling and sound-absorbing underlay mat (10 mm thick) or as per manufacturer specification.

Pump arrangement shall be vertical/ horizontal outlet with integrated non-return valve, with/without closure valve (provided loose), with hose section or flange.

6.8 SCUPPER DRAIN OUTLET / RAINWATER OUTLET

6.8.1 SCOPE

Rainwater outlet shall be preferably scupper type drain with cast iron body and cast aluminium grating with stainless steel screws. Suitable adapter/ connector shall be used to match the pipe. Wherever shafts are not available near rainwater outlet, dome type rain water outlet shall be installed.

Rain water outlet shall be tested for water leaking, prior to waterproofing treatment. Extreme care shall be taken, while sealing gap between rain water outlet and wall/ slab.

6.8.2 MATERIAL

- a. The Scupper drain shall be of SS 304 Stainless Steel material with perforation or solid top, depending on the application.
- b. A perforated top grating shall be used for floor drains expected to receive surface water. The perforated top grating shall be free of any defects and shall have a uniform thickness.
- c. A solid top grating shall be used for such applications where in the content of the waste water contains such foul elements which would affect the local environment.

The solid cover shall have a complete sealing

- d. The solid top grating shall be free of any defects and shall have a uniform thickness.

6.8.3 FIXING

SS 304 Stainless Steel grating shall be fixed in position with appropriate and durable sealant and screw and nuts.

6.8.4 RATES

- a. Stainless Steel scupper drain out shall be with perforating grating.
- b. Fixing the grating with all required material.
- c. Making all damage good to original condition after completion of installation work.
- d. All necessary materials, labor and use of tools.

6.9 PUDDLE FLANGE

6.9.1 SCOPE

MS hot dip galvanized PUDDLE FLANGES fabricated out of 6 mm thick MS plates of suitable size and IS:1239 heavy class pipes properly fixed in walls & top slab of tanks. The entire fittings shall be hot dipped galvanized after fabrication. Length shall be minimum 600 mm or wall thickness plus 200 mm on either side (whichever is more).

6.9.2 MATERIAL

Puddle flange fabricated out of 6 mm thick MS plates of suitable size shall be used.

6.9.3 FIXING

Puddle flange shall be fixed in position with appropriate location during construction phase.

6.9.4 RATES

- a. Puddle flange shall be taken
- b. Installation shall be done with necessary construction material.
- c. Making all damage good to original condition after completion of installation work.
- d. All necessary materials, labour and use of tools.

6.10 BLANK FLANGE

6.10.1 SCOPE

Blank flanges shall use at non-used / spare puddle flange. Jointing shall be done with bolts, nuts, washers and rubber insertion 3 mm thick, testing the flange and joints etc.

6.10.2 MATERIAL

Blank flange fabricated out of 6 mm thick MS plates of suitable size shall be used.

6.10.3 FIXING

Blank flange shall be fixed in position with appropriate location during execution phase.

6.10.4 RATES

- a. Blank flange shall be taken
- b. Installation shall be done with necessary execution stage.
- c. Making all damage good to original condition after completion of installation work.
- d. All necessary materials, labour and use of tools.

6.11 STEPS/FOOTREST/RUNGS**6.11.1 SCOPE**

Steps shall be provided wherever the depth of the manhole / chamber is more than 1.2 m. Foot rest plastic encapsulated as per IS : 10910, on 12 mm dia steel bar conforming to IS: 1786, having minimum cross section as 23 mmx25 mm and over all minimum length 263 mm and width as 165 mm with minimum 112 mm space between protruded legs having 2 mm tread on top surface by ribbing or chequering besides necessary and adequate anchoring projections on trail length of 138 mm.

As per standard drawing or suitable to with stand the bend test and chemical resistance test as per specifications and having manufacture's permanent identification mark to be visible even after fixing, including fixing in manholes with 30x20x15 cm cement concrete block 1:3:6 (1 cement: 3 coarse sand : 6 graded stone aggregate 20 mm nominal size) complete as per design.

Footrest shall be placed 300 mm apart vertically and 375 mm horizontally in staggered fashion. First footrest shall be 450 mm below top. Footrest shall be painted with

bituminous paint and the portion embedded shall be painted with thick cement slurry before fixing.

6.11.2 MATERIAL

The footstep shall be plastic encapsulated steel bar material.

6.11.3 FIXING

Footrest shall be fixed in position with appropriate and during construction work.

6.11.4 RATES

- a. Footrest shall be steel bar plastic incapsulated.
- b. Fixing the foot rest with all required material.
- c. Making all damage good to original condition after completion of installation work.
- d. All necessary materials, labour and use of tools.

6.12 GI VENT WITH BRASS MOSQUITO PROOF COUPLING

GI vent with brass mosquito proof coupling and air filter including return bend shall be provided. GI pipe of C Class shall be used and minimum height of vent shall not be less than 800 mm. The entire fitting shall be hot dip galvanised.

6.13 DRAIN CHANNEL

6.13.1 SCOPE

Drain channel shall be used for pump room surface drainage. Supplying and fabricating by welding / electroforging, and fixing in position Heavy duty MS structural steel 25mm thk grating work made up of flats and roads including all necessary fixtures, fasteners, all material and labour complete in all respects. The grating shall be hot dip galvanised to 610grams/sgm.

6.13.2 RATES

Rate shall include grating, drain channel, fittings and all necessary materials, labour and use of tools.

6.14 MULTI TRAP**6.14.1 SCOPE**

The item pertains to provide Multi traps with grating including fixing, testing & commissioning.

6.14.2 MATERIAL & FIXING

- a. The trap shall be of cast iron as specified in schedule of quantities.
- b. The trap shall be provided with SS/ CP brass grating of size 100/150 mm size as specified in schedule of quantities.
- c. Multi trap shall have generally water seal not less than 50 mm.
- d. The trap shall have 100 mm floor inlet & 40/50/75 mm single outlet.
- e. The trap shall be fixed in PCC 1:2:4 100 mm around up to finished floor with watertight finishing & shall be firmly supported on structural floor.

6.14.3 RATES

- a. Multi trap with grating cover.
- b. Jointing & fixing material.
- c. Making all damage good to original condition after completion of installation work.
- d. Testing the entire system and rectification of defects if any.
- e. All necessary materials, labour and use of tools.

6.15 NAHNI TRAP**6.15.1 SCOPE**

The item pertains to provide Nahni traps with grating including fixing, testing & commissioning.

6.15.2 MATERIAL & FIXING

- a. The trap shall be of cast iron as specified in schedule of quantities.
- b. The trap shall be provided with SS/ CP brass grating of size 100/150 mm size as specified in schedule of quantities.

- c. Nahni trap shall have generally water seal not less than 50 mm.
- d. The trap shall have 100 mm floor inlet & 40/50/75 mm single outlet.
- e. The trap shall be fixed in PCC 1:2:4 100 mm around up to finished floor with watertight finishing & shall be firmly supported on structural floor.

6.15.3 RATES

- a. Nahni trap with grating cover.
- b. Jointing & fixing material.
- c. Making all damage good to original condition after completion of installation work.
- d. Testing the entire system and rectification of defects if any.
- e. All necessary materials, labour and use of tools.

TECHNICAL SPECIFICATIONS FOR SEWAGE TREATMENT PLANT

CONTENTS

CONTENTS.....	2
1.0 SEWAGE TREATMENT PLANT PHILOSOPHY	3
2.0 SCOPE OF WORK FOR SEWAGE TREATMENT PLANT	3
3.0 SPECIFIC REQUIREMENTS/ INSTRUCTION TO BIDDERS.....	4
4.0 TREATMENT SCHEME	7
5.0 SCOPE OF WORK.....	10
6.0 OPERATION PHILOSOPHY	15
7.0 STP – CIVIL/MSEP WORKS	17
8.0 DATA TO BE FURNISHED BY CONTRACTOR AFTER AWARD OF CONTRACT ..	39
9.0 DELETED.....	42
10.0 TECHNICAL SPECIFICATIONS FOR MECHANICAL EQUIPMENT AND COMPONENTS FOR SEWAGE TREATMENT PLANT	49
11.0 TECHNICAL SPECIFICATIONS FOR INSTRUMENTATION & CONTROL FOR SEWAGE TREATMENT PLANT, CTBD EFFLUENT TREATMENT PLANT AND REVERSE OSMOSIS SYSTEM	82
13.0 STRUCTURAL DESIGN CONSIDERATION FOR STP	233

1.0 SEWAGE TREATMENT PLANT PHILOSOPHY

Sewage Treatment Plant (STP) will be designed to remove the contaminants from sewage as per the norms specified by guidelines and produce treated sewage deemed fit for recycling for non-potable purposes such as irrigation (landscaping), flushing, HVAC requirements. In line with sustainable infrastructure plan, 100% sewage is proposed to be treated to the required standards and recycled for the non-potable purposes.

Based on the water demand and wastewater estimates, the ultimate Sewage generation from phase I building, is about 239 KLD. The STP shall be design for the 250 KLD capacity with 22 hours of operation. The estimated flow of cooling tower blowdown (CTBD) water which shall eventually conveyed to STP is 68 KLD. Filtered sewage shall be further subjected to RO system.

2.0 SCOPE OF WORK FOR SEWAGE TREATMENT PLANT

The scope includes but not limited to the design, detailed engineering, construction, manufacture, procurement and supply of all materials and equipment, receipt, storage, conservation & preservation of all materials including all civil, structural steel works (sheds, platforms, ladders, etc.), interconnecting piping, electrical, instrumentation, fabrication, painting, inspection & testing at bidder's works, packing, forwarding, transportation, transit insurance, delivery at site, erection/installation, testing, commissioning, carrying out performance / acceptance guarantee test runs, training to client's manpower for O&M of STP and handing over of STP as described hereunder and in various other referred documents including the Specifications and Data Sheets attached herein.

Scope broadly covers the following but not limited to:

- STP has to be constructed below ground in basement at OSR area.
- Outer Plan dimension of STP shall be within 34.5 m x 12.5m as indicated in the tender drawing.
- Prepare and submit GA and structural drawings (GFC) as per documents and drawing submission & distribution schedule.
- The equipment to be supplied and erected as detailed in BOQ and these shall be in accordance with Specification and the relevant data sheets section.
- Piping inside and around STP including suction and delivery piping, delivery header, recirculation piping including all the valves.
- Supporting arrangements needed (indoor & outdoor) for the piping, valves, and instrumentation.
- Proper ventilation and entry / exit staircases shall be provided to access the underground units of STP. Cut-outs, vents have to be provided in the roof slab.
- Emergency power backup is to be provided for Air blowers and Return Sludge Pumps.

- Cut-outs, vents have to be provided in the roof slab of underground Treatment Units if any for operation and maintenance purposes and for lifting of pumps.
- Entry / Exit staircase have to be provided to access the STP
- Any item which may not have been specifically mentioned herein but are needed to complete the equipment / system shall also be treated as included and the same shall also be furnished and erected, unless otherwise specifically excluded as indicated.
- A discharge pipe of the Equalised sewage transfer pumps shall be provided from the Equalisation tank along with blind flange to filter feed tank / nearest drain manhole leading to external sewer network. (To be used exceptionally in case of major breakdown only)

3.0 SPECIFIC REQUIREMENTS/ INSTRUCTION TO BIDDERS

3.1 QUANTITY

The total maximum wastewater inlet at Sewage Treatment Plant (STP) has been calculated as 250 KLD. The STP is being proposed to be constructed on Membrane Bio Reactor (MBR) technology. Considering the varying population STP shall be designed on modular basis. All the units generally designed on hydraulic loading rate / retention time shall be designed for the ultimate capacity including sludge handling system.

The estimated flow of cooling tower blowdown (CTBD) water which shall eventually conveyed to STP is 70 KLD.

Units which are designed on organic loading rate shall be on modular basis. It is proposed to design the organic units in modules of 2 x 50%. Moreover, each module shall be able to operate with 50% turndown ratio to take care of varying population during initial phase.

The STP capacity and expected characteristics of the raw and treated sewage generated to be guaranteed by bidder are presented in Table 1.1 & Table 1.2 . Bidder must give confirmation in Table 1.2 upon its agreement.

Table 1: Plant Capacity

Sl. No.	Description		STP
1	Raw Sewage (Normal Flow)	:	250 KLD
2	Peak factor	:	3
3	Plant operating Time	:	22 Hours per day
4	Sludge dewatering system operating time	:	16 Hours per day
5	Treatment Process	:	Membrane Bioreactor (MBR) Technology

6	CTBD Effluent	:	70 KLD
8	CTBD Effluent Treatment Plant operating Time	:	20 Hours per day
9	RO system	:	200 KLD
10	RO system operating Time	:	20 Hours per day

Table 2: Design Basis

Sr. No.	Parameters	Unit	Values
A	Raw Sewage Characteristics		
1.	pH		6.5 to 8.0
2.	COD	mg/L	400 to 500
3.	BOD, 5 days @ 20°C	mg/L	250 to 300
4.	Suspended solids	mg/L	300 to 400
5.	Total Nitrogen	mg/L	50
6.	Organic Nitrogen	mg/L	15
7.	Ammonia Nitrogen	mg/L	35
8.	Nitrate Nitrogen	mg/L	5
9.	Total Phosphorous	mg/L	7-8
10.	Oil & grease	mg/L	25 to 50
B	Anticipated Quality of Cooling Tower Blow-Down		
1.	pH		6.5 to 9.0
2.	Hardness	mg/L as CaCO ₃	< 750
3.	Alkalinity	mg/L as CaCO ₃	< 500
4.	Total Dissolved Solids	mg/L	< 1100

Sr. No.	Parameters	Unit	Values
5.	Conductivity	micromhos	<2000
6.	Chlorides as Cl	mg/L	<200
7.	Sulphates	mg/L	<500
8.	Silica	mg/L	<75
9.	Total Phosphorous	mg/L	7-8
10.	TSS	mg/L	<100
C	Treated Sewage Characteristics for Reuse		
	For Toilet Flushing		
1	pH		6.5–8.3
2	Oil & Grease	mg/l	<5
3.	Total suspended solids	mg/L	<5
4	BOD	mg/l	<6
5.	COD	mg/L	<50
6.	Total nitrogen (N)	mg/L	<10
7.	Total phosphorous	mg/L	<2
8.	Coli forms	CFU per 100mL	Nil
9.	Turbidity	NTU	<2
10.	Total Dissolved Solids, mg/lit	mg/L	<2100
D	For Land Application		
1	pH		5.5-9.0
2.	TSS	mg/l	20
3.	BOD5	mg/l	<10
4.	COD	mg/l	<50
5	Oil & Grease	mg/l	<10
6.	Total Nitrogen	mg/l	<10
7.	Total Phosphorous	mg/l	<1

Sr. No.	Parameters	Unit	Values
8.	Faecal Coliforms	MPN/	Nil
9.	Turbidity	NTU	-
10.	Total Dissolved Solids	mg/l	< 2100
C	For HVAC Requirements		
1.	pH		6.5-8.3
2.	Hardness, as CaCO ₃	mg/l	< 50
3.	Total Dissolved Solids	mg/l	< 250

4.0 TREATMENT SCHEME

4.1 SEWAGE TREATMENT PLANT

The raw sewage shall be passed through Screen chamber in which coarse screen shall be followed by fine screen. Screened sewage shall pass through other treatment units such as Oil & Grease trap followed by Equalisation tank, biological treatment units employing Membrane Bio Reactor (MBR).

For Cooling tower blowdown treatment, it is proposed to have media filtration followed by ultrafiltration system. From CTBD collection tank, CTBD blowdown is pumped to the PSF followed by micron filter and UF. The ultrafiltration (UF) system functions as an advanced and efficient pretreatment for downstream RO system.

Ultrafiltered cooling tower blowdown shall be mixed with the treated sewage and the blended water shall be fed to reverse osmosis system. Permeate from the RO system shall be used for cooling tower make-up and reject shall be used for irrigation.

The raw sewage shall enter in screen chamber by gravity and subjected to coarse screen followed by fine screen to remove the floating materials, plastics, papers, etc. The screened materials shall be collected and safely disposed off by the Contractor. The screened sewage shall flow by gravity to Oil and Grease trap and Equalisation Tank.

Oil and grease trap chamber shall be essentially provided with baffle wall with adequate detention time for the physical separation of floating oil. Separated oil shall be collected through oil skimmer and disposed off by contractor. The grit settled in the oil and grease trap shall also be removed periodically and disposed off by the Contractor.

The degritt / deoiled sewage shall be collected in the equalisation tank which shall serve as balancing tank to store the excess flows during peak hours and to supply the composite sewage to the downstream units during the lean period so as to maintain constant average flow rate at downstream units of the plant. Air shall be supplied at the bottom of equalisation tank with the

help of Air blowers and air grid to keep sewage in mixed condition in the tank and to avoid septic condition in the tank.

Equalised sewage from Equalisation tank shall be transferred to the biological system to degrade organic matter such as COD and BOD.

Biological Treatment - (Anoxic & MBR):

To reduce the Nitrogen level in sewage up to desired level, Nitrification- Denitrification process is adopted. Sewage from equalisation tank shall be pumped to fine screen followed by Anoxic Tank and MBR System. Anoxic Tank is introduced for Denitrification process. Anoxic Tank comprises of a slow-moving submersible mixer. Sewage from anoxic tank enters in the aeration tank followed by MBR tank.

The design shall consist of Two biological module/train, each module with an anoxic tank, an aeration tank and a membrane tank.

Nitrate formed in the aeration and membrane tank, is recycled back to the anoxic tank where it is denitrified. Each Anoxic tank shall consist of one submersible mixer for mixing the sewage with recycle sludge from membrane tanks. For Denitrification, DO shall be maintained 0.1-0.2 mg/lit in Anoxic tank. Having the anoxic zone as a first zone, allows for maximum influent BOD utilization for denitrification. The sewage shall overflow from the anoxic tank to aeration tank. Fine bubble diffusers shall be provided at the bottom of aeration tank to supply oxygen for biological decomposition of organic matter and to keep the mixed liquor suspended solids (MLSS) in suspension. Air blowers shall be provided to supply oxygen to aeration tanks. Dissolved oxygen will be monitored in aeration tank. The Air blowers shall be provided with VFD.

Membrane Tank

The mixed liquor from aeration tank shall be overflowed in membrane tank consisting of submerged membrane modules. Clean water shall be withdrawn from the mixed liquor through the membranes using permeate pumps. Permeate shall be taken from the backpulse water tank/ Membrane Permeate Tank for backpulsing and cleaning the membranes. Backpulse pumps shall be used for cleaning the membranes. The sludge from the membrane tank shall be recycled to anoxic tanks using Return sludge transfer pumps. Excess sludge shall be transferred to a sludge holding tank. The permeate and backpulse pumps shall be provided with VFD. Citric Acid and NaOCl Dosing system shall be provided for cleaning.

Disinfection Unit

Sodium hypochlorite solution shall be dosed in the MBR Permeate tank to maintain residual chlorine for water reuse.

MBR Permeate Tank

The treated sewage from MBR Permeate tank shall be collected and used for flushing. MBR Permeate shall be transferred for flushing with the help of Flushing Water transfer Pumps.

The part of treated sewage shall be transferred to the RO Feed Tank where it gets blended with UF Treated CTBD effluent.

Service Water & Instrument Air

The treated sewage from the MBR Permeate Tank shall be used as service water for washing of screenings, flushing and chemical solution preparation.

If required, for operation of various pneumatically operated valves Instrument air shall be provided with the help air compressors. Air Compressor along with receiver tank, and air - dryer shall be provided for operating pneumatic valve actuators.

Sludge Handling

Excess sludge from MBR tanks, shall be removed periodically and collected in Sludge Holding tank. Compressed air shall be supplied to keep the sludge in suspension and to avoid anaerobic condition in the tank. The Sludge from the sludge holding tank shall be pumped to the Decanter Centrifuge for mechanical dewatering. For better flocculation, Dewatering Polyelectrolyte would be dosed. The dewatered sludge can be used as a soil conditioner. The Centrate from Decanter centrifuge will be taken by gravity into the Equalisation Tank.

4.2 COOLING TOWER BLOWDOWN TREATMENT

For Cooling tower blowdown treatment, it is proposed to have media filtration followed by ultrafiltration system.

From CTBD collection tank, CTBD blowdown is pumped to the PSF followed by micron filter and UF. The ultrafiltration (UF) system functions as an advanced and efficient pretreatment before the reverse osmosis (RO) system, aiming to attain superior water quality. This is achieved by utilizing a semi-permeable membrane to physically separate impurities from the water, ensuring that only purified water molecules pass through.

In this process, pressurized water is forced through the membrane, which features microscopic pores, typically in the range of 0.01 to 0.1 micrometers. These pores allow water molecules to pass through while blocking contaminants such as bacteria, viruses, suspended solids, and macromolecules. The UF system operates on the principle of size exclusion or molecular weight cutoff, ensuring that only particles smaller than the pore size can permeate the membrane.

Ultrafiltered cooling tower blowdown shall be mixed with the treated sewage and the blended water shall be subjected to reverse osmosis system. It is proposed to have 200 KLD of RO system. Permeate from the RO system shall be used for cooling tower make-up and reject shall be used for irrigation.

The dirty backwash from CTBD treatment shall be sent to STP.

4.3 RO SYSTEM

The ultrafiltered blowdown water shall be blended with treated sewage in the CTBD UF permeate tank the same tank will be act as RO feed tank.

Blended feed (Treated sewage + ultrafiltered CTBD) from RO feed tank shall be pumped to the downstream Micron Cartridge Filters (MCF) prior to RO system.

In order to prevent scaling of RO Membranes, RO feed shall be dosed with suitable antiscalant solution and shall be dechlorinated with Sodium Meta Bi Sulphite (SMBS). pH correction shall also be carried out if required.

MCF shall be designed to trap any colloidal particles of size of 5 micron and greater. Micro filtration shall eliminate possibility of regular clogging of the RO membrane surface. Filtered sewage from MCF shall be pumped to RO unit by High Pressure Pumps.

The RO units shall be designed such that minimum 55% volumetric recovery is obtained and consistent and continuous permeate is produced all the time.

RO membranes shall be flushed/ cleaned whenever required using chemical solutions specified by membrane manufacturers. RO Clean in Place System (CIP) shall be provided which will be used infrequently for membrane cleaning.

RO Permeate will be stored in RO permeate tank from where it will be transferred to the HVAC UGTs whereas RO reject will be collected in RO reject tank and 48 KLD of total reject water with <2100 ppm TDS will be transferred to the irrigation water tank. Rest of reject water will be disposed of or used for the secondary purposes by the bidder.

5.0 SCOPE OF WORK

5.1 Design, detailed engineering, structural detailed design and calculations, structural and reinforcement drawings, construction, manufacture, procurement and supply of all materials and equipment, receipt, storage, conservation & preservation of all materials including all civil, structural steel works (sheds, platforms, ladders, etc.), interconnecting piping, electrical, instrumentation, fabrication, painting, inspection & testing at bidder's works, packing, forwarding, transportation, transit insurance, delivery at site, erection/installation, testing, commissioning at site and carrying out performance / acceptance guarantee test runs, operating and maintenance of the STP (250 KLD), CTBD Effluent Treatment plant (70 KLD) and Reverse osmosis system (200KLD) during defects liability period; described hereunder and in various other referred documents including the Specifications and Data Sheets attached herein

FOR STP- 250 KLD

- a) Manual Screen chamber (1 No.) MOC-RCC
- 1 No. Coarse Bar screen- 10 mm opening, MOC- SS 316.

- 1 No. Fine Bar screen- 6 mm opening, MOC- SS 316.
- b) Oil and Grease Tank (1 No.) MOC-RCC,
 - 1 No. Slotted pipe Oil skimmer, MOC- MSEP
- c) Equalisation Tank (1 no.) - MOC-RCC, with level transmitter
 - Retention time- Minimum 8 hrs
 - Air Blowers along with Acoustic enclosure - 2 Nos. (1W+1S),

same shall be used for Sludge Holding Tank, MOC- CI

- 1 Nos. Coarse bubble perforated pipe air grid, MOC- UPVC
- Equalised Sewage Transfer Pumps-3 Nos. (2W+1S), 1W for each module and 1 common standby, submersible cutter type pumps with accessories. For transferring equalised sewage to Anoxic tank. MOC- CI with SS Impeller and shaft. Suitable lifting arrangement for maintenance.
- Equalised Sewage bypass Pumps-2 Nos. (1W+1S), submersible cutter type pumps with accessories. For transferring equalised sewage to external sewer in emergency or plant shutdown. MOC- CI with SS Impeller and shaft. Suitable lifting arrangement for maintenance.
- d) Drum screen prior to anoxic tank- 2 mm punched hole, MOC- Body-CS,

Drum- SS 304.

- e) Anoxic Tank- 2 Nos. (1 No. for each module), MOC-RCC, Each with Submersible Mixer
 - 1 No., MOC- SS 304
- f) Aeration Tank – 2 Nos. (1 No. for each module), MOC-RCC.
 - Minimum HRT – 6 hrs
 - Process Air Blowers (VFD) along with Acoustic enclosure - 3 Nos. (2W+1S), 1W for each module and 1 common standby, MOC-CI
 - Fine bubble, non-clog, retrievable diffusers for diffused aeration, 2 Lots (1 Lot for each module), Membrane MOC- EPDM
 - DO meter, 2 Nos. 1 No. for each tank.
- g) MBR Tank- 2 Nos. (1 No. for each module), MOC-RCC,
 - Membrane Frame- SS
 - Membrane modules - 2 Lots (1 Lot for each tank), MOC- PVDF. Suitable lifting arrangement for maintenance/replacement. Lifting arrangement of membrane for maintenance / replacement if at all surfaces above ground have to be covered up by Mumty.
 - Nitrifying liquor Recirculation Pumps / Return sludge Pumps - 3 Nos. (2W+1S), 1W for each module and 1 common standby, Nitrifying liquor Recirculation Pumps and accessories for transferring mix liquor from MBR tank to Anoxic tank. MOC-CI with SS Impeller. Same pump can be used to transfer excess sludge in to Sludge Holding Tank.
 - Membrane Air Blowers (VFD) along with Acoustic enclosure - 3 Nos. (2W+1S), 1W for each module and 1 common standby, MOC-CI.

- MBR Permeate Pumps (VFD)- 3 Nos. (2W+1S), 1W for each module and 1 common standby,
- Membrane Cleaning system- 2 Sets (1 set for each module), Each set consists,
 - o Sodium hypochlorite Dosing tank (1 No), MOC- HDPE, and Dosing pumps, 2 Nos. (1W+1S), MOC-PP.
 - o Citric Acid Dosing tank (1 No), MOC- HDPE, Agitator, 1 No. MOC- SS 304 and Dosing pumps, 2 Nos. (1W+1S), MOC-PP.
- h) MBR Permeate Tank/ Backpulse Tank- 1 No. MOC-RCC, with level transmitter
 - Retention time- Minimum 2 hrs
 - Back pulse pumps (VFD)- 3 Nos. (2W+1S), 1W for each module and 1 common standby, MOC- CI with SS impeller.
- i) Disinfection
 - Sodium hypochlorite Dosing tank (1 no), MOC- HDPE, and Dosing pumps, 2 Nos. (1W+1S), MOC-PP.
- j) MBR permeate transfer Pumps - for transferring MBR permeate to RO feed tank – 2 Nos. (1W+1S), MOC-CI with SS shaft and Impeller.
- k) Sludge Dewatering System
 - Sludge Holding tank 1 No. MOC-RCC, with level switch,

Min HRT – 24 hrs

- Coarse bubble perforated pipe air grid, MOC- UPVC, with Air blowers (Common Air blowers shall be used to supply compressed air in Equalisation tank and Sludge Holding tank), MOC-CI
- 2 Nos. (1W+1S) Centrifuge Feed Pumps, MOC- CI with SS impeller
- Decanter Centrifuge, MOC- CI, Wetted parts-SS 316
- Dewatering Polyelectrolyte dosing tank -1 No MOC-HDPE, Agitator – 1 No., MOC- SS 304,
- Dewatering Polyelectrolyte dosing pumps 2 Nos. (1W+1S) MOC-PP.

FOR CTBD Effluent Treatment - 70 KLD

- a) CTBD Collection Tank- - 1 no., MOC-RCC, Minimum HRT: 4 hours
- b) Filter Feed Pumps - 2 Nos. (1W+1S), MOC-CI with SS Impeller. For transferring CTBD effluent to Pressure Sand Filter (PSF) / Activated Carbon Filter (ACF).
- c) Pressure Sand Filters (1W) – Filtration velocity 15 m/hr , MOC – MSEP

- d) Activated Carbon Filters (1W) - Filtration velocity 12 m/hr , MOC – MSEP
- e) UF feed tank - 1 no. , MOC-RCC, Minimum HRT: 2 hours
- f) UF Feed Pumps - 2 Nos. (1W+1S) , MOC-CI with SS shaft and Impeller. For transferring filtered sewage to UF skid.
- g) Skid mounted Ultrafiltration system for 70 KLD capacity and minimum 95% recovery rate with CEB and CIP System- 1 Set. Type- Dead End, Pressure Driven, Fully automatic.
- Bag Filter Bag MOC: Polypropylene Housing: SS 304
 - UF skid MOC: SS 304
 - UF Membrane MOC- PVDF Polymer or polysulfone
 - UF backwash pumps (VFD driven)- 2 nos. (1W+1S) MOC-CI with SS shaft and Impeller.
 - Handheld SDI kit and arrangement to measure the SDI in UF permeate
 - UF CEB / CIP system consisting of Chemical Feed Tank 1 No., MOC- HDPE, Chemical Feed Pumps 2 Nos. (1W+1S)
- h) UF & MBR Permeate Blending Tank/ RO Feed Tank - 1 no. for handling 200KLD flow, MOC-RCC, Minimum HRT : 2 hours

FOR RO system - 200 KLD

- a) Skid mounted RO System consisting of:
- Recovery minimum 55%
 - RO Feed Pumps 2 Nos. (1W+1S)
 - RO skid MOC: SS 304
 - Micron Cartridge Filter (MCF) with SS 304 housing
 - Anti-scalant dosing system- Dosing Tank 1 No., MOC- HDPE, PP Dosing Pumps 2 Nos. (1W+1S)
 - SMBS Dosing System- Dosing Tank 1 No.- MOC- HDPE, PP Dosing Pumps 2 Nos. (1W+1S)
 - RO High Pressure Pumps 2 Nos. (1W+1S) MOC: SS 316
 - RO Pressure Tubes (MOC: FRP) with RO Membranes (MOC: Polyether sulfone / Polysulfone)
 - pH correction dosing system
 - RO CIP (Cleaning-in-Place) System
 - 1 No. Cartridge Filter
 - CIP Tank 1 No., MOC- HDPE, Chemical Feed Pumps 2 Nos. (1W+1S).
- b) RO Permeate Tank - 1 no., MOC-RCC, Minimum HRT : 2 hours

- c) RO Reject Tank - 1 no., MOC-RCC, Minimum HRT : 2 hours
- d) MCC/PLC Room, 1 Nos. 1 along with cables and cable trays
 - MCC Panel- 1 No. Compartmentalised
 - PLC Panel- 1 No. for Fully Automatic operations of MBR, UF & RO system
- e) If required, Instrument air compressor with an air receiver tank, air filter-dryer and air filter regulator along with instrument air piping and tubing for pneumatically operated valves.
- f) Proper mechanical ventilation and entry / exit staircases shall be provided to access the underground units of STP. Cut-outs, vents have to be provided.

5.2 Submission of Plant Layout, Process Design and Hydraulic Flow Diagram, Single Line Diagram, P&I Diagram.

5.3 Structural Detailed design and calculations, Detailed Plant Layout, Detailed GA, and structural drawings, Detailed GFC drawings, Piping layout, Hydraulic Flow Diagram, Single Line Diagram, P&I Diagram, GA drawings with sectional drawings, Fabrication Drawings, Technical datasheets, selection of equipment, preparation of the drawings for the complete STP operation to the requirement as stipulated in this specification.

5.4 Contractor shall provide the details for equipment foundations drawings, GA, and structural drawings of the civil units, opening, sleeves and cut outs in structures, etc. complete.

5.5 Removal of screened material, floating oil, and its disposal, The transportation and disposal of screened material, dewatered sludge and oil is in Contractor Scope during DLP period

5.6 Provision of primer and finishing coats painting to all civil and metal pipe work and auxiliary equipment as stated in the specification.

5.7 Static testing of equipments.

5.8 Trial Run, Testing and Commissioning of the plant under normal operational conditions.

5.9 Provision of test reports from Third party NABL accredited laboratory after the commissioning of the plant. Quality of the Incoming raw sewage and outgoing treated sewage shall be included. Parameters shall be analysed as given in the specifications.

5.10 Sealing gaps between pipe sleeves and pipe work/ conduit, etc. if any.

5.11 A complete package submission to local government authority for approval and obtaining license/ consent for establishment/ consent for operation of the plant will be in the scope of the Contractor.

5.12 Preparation and submission of Operation and Maintenance Manual as detailed elsewhere in the specification.

5.13 The MBR, UF and RO membranes shall be replaced free of cost in case of any kind of performance deterioration during the membrane warranty period. Membrane warranty shall be minimum 5 years from the date of commissioning.

6.0 OPERATION PHILOSOPHY

6.1 MBR Technology

The Overflow of the Aeration Tank comes into respective MBR Tank. To control the level of the Tanks Ultrasonic Level Transmitters shall be provided in the MBR tank. Both Level Transmitters are interlocked with MBR Suction Pumps/ MBR permeate pumps. MBR permeate Pumps will start when MBR Tank level goes high from Set Value.

Level transmitter shall be also interlocked with Equalised Sewage Transfer Pumps. The Equalised Sewage Transfer Pumps will stop when level in MBR tank level goes high from set Value.

Sludge from the bottom shall be recycle back to the Anoxic Tank & Aeration tank to maintain the desired MLSS and excess sludge shall be transfer to Sludge Holding Tank. To monitor the Turbidity of MBR Permeate, Turbidity Meter & Pressure Transmitter at each MBR Tank Permeate line or MBR Permeate pump suction line.

Flow Meter shall be provided at MBR permeate Pump suction line to monitor & Totalize the Flow of the MBR Treated Water.

Turbidity Meter, Pressure Transmitters & Flow Meters shall be interlocked with VFD of the MBR Permeate Pumps.

The Membrane Operating System is an assembly with integral membrane modules arranged in rack assemblies, inserted into the membrane tank. MOS Mixed Liquor Distribution & Recirculation Jets are designed to distribute the air scour and mixed liquor flow evenly across the membrane sub modules. This feature eliminates potential polarization (concentration) of suspended solids around the membrane fibers which could be main cause for the failure and damage of individual fibers thus sub modules. Additionally, this feature provides even distribution of mixed liquor solids to each membrane unit, critical so that all membranes see the same process conditions. The return recirculation of mixed liquor ensures influent comes in intimate contact with the concentrated biomass, offering better organism selection and added flexibility in the anoxic cycle for advanced nitrogen removal, when required. This same system also acts as an integral part of the membrane cleaning system, providing an efficient scouring of the membranes with chlorine cleaning solution. The integrated cleaning system allows the sub modules to be quickly cleaned in place. Additionally, the clean and efficient procedure eliminates the need for membrane removal from process tanks that can damage membranes and present risks to plant-operators. Relaxation, Maintenance and in site CIP are exclusive features of this MBR Process to ensure consistent water quality and complete membrane life. The entire operation is PLC controlled.

i. Filtration and Relaxation Mode

Relaxation time, in which membrane surface cleaning is conducted, must be provided between suction intervals for stable treatment using the MBR system.

ii. CIP Mode

There are three types of chemical cleaning using sodium hypochlorite and/or acid. Two type of chemical cleaning required for MBR System. Maintenance/Weekly cleaning and recovery cleaning. Cleaning procedures shall be as per MBR manufacturers guidelines.

6.2 UF RO System Technology

Treated sewage would be received and collected in MBR Permeate Tank. Level transmitter shall be installed in the MBR Permeate Tank. At low level, Filter Feed pump shall trip.

Sodium Hypochlorite shall be dosed on-line at inlet of Pressure Sand Filter. The operation of Pressure Sand Filter shall be manual. Pressure gauges shall be provided at the inlet and outlet line of Pressure sand filter. Based on Pressure difference, backwashing shall be done which will be minimum once in 24 hours. Dirty Backwash water from the filtration system shall be sent to Irrigation tank/ Equalisation tank in STP. For Filter backwash same Filter feed pumps shall be used for backwashing of Filters.

CTBD Effluent from Pressure Sand Filter shall be collected in UF Feed Tank.

Level transmitter shall be provided in the UF Feed Tank. At high level, Filter Feed Pumps shall trip. At low level, UF Feed pump shall trip.

Bag filter provided upstream of UF shall have Differential Pressure Switch across the Bag filter. Based on Pressure difference required maintenance shall be carried out.

Filtered water from Bag filter shall pass through dead end type UF system which shall be fully automatic. UF system will have periodic backwash due to rise in trans-membrane pressure on account of accumulation of solids from the incoming water during the filtration cycle. Chemically Enhanced Backwash (CEB) system shall be provided for periodic chemically cleaning of UF membranes. UF backwash and CEB wash water will be routed to irrigation tank/Equalisation tank in STP. Cleaning In Place (CIP) system shall also be provided which will be used infrequently. Same CEB set-up shall be used for CIP as and when required. For CEB / CIP tanks level switch shall be provided and pumps shall trip at low level. Dedicated UF backwash pumps shall be used for backwashing of UF.

UF Permeate Tank will receive 65 KLD treated CTBD Effluent from UF System and 129 KLD of treated sewage from STP MBR Technology. Blended CTBD UF permeate and MBR permeate shall be pumped to the downstream Micron Cartridge Filters prior to RO system. Level transmitter shall be provided in the UF permeate tank, at high level UF feed pump shall trip and at low level, RO Feed pump shall trip. At High level in RO permeate tank in STP, RO feed pump shall trip.

Antiscalant & SMBS (Antioxidant) shall be dosed at inlet of RO System prior to Micron Cartridge Filter. Antiscalant is used to control carbonate scaling, sulfate scaling and calcium fluoride scaling. Scale Inhibitors have a “threshold effect”, which means that minor amounts adsorb specifically to surface of micro-crystals thereby preventing further growth and precipitation of crystals.

Furthermore, free chlorine present in the filtered water may result in chemical oxidation of the membranes. Hence anti-oxidant is injected at the inlet of the cartridge filter to eliminate any

oxidizing elements being present in the raw water and to protect the membranes, which are the most vital part of the plant. During startup, required amount of anti-oxidant is determined by inspection based on ORP in filtered water. If chlorine level at the inlet of RO system is higher than the desired value, then dump valve will open automatically and shall flow back to UF permeate tank/ Flushing Water tank.

Level switch shall be installed in all dosing tanks. At low level in dosing tanks, Dosing pumps shall trip.

Online analyzers are provided on the RO feed water line before cartridge filters to continuously monitor the RO feed water quality.

Differential Pressure Switch should be provided across the Micron Cartridge filter. Based on Pressure difference, required maintenance shall be carried out.

Suitable automation shall be provided, as low level in UF Permeate Tank, RO Feed pump shall trip resulting low pressure in suction and discharge line of High-pressure pumps. Alarm shall be annunciated and high-pressure pump shall also trip.

At higher pressure than the design pressure in discharge line of RO high pressure pumps, RO High pressure pumps will trip.

RO unit is equipped with inlet pressure transmitter, intermediate pressure transmitter and reject pressure transmitter. RO permeate and reject flow is monitored by online flow transmitters and flow meters. RO Permeate water quality is monitored by means of an online pH and Conductivity transmitter, at high level in conductivity meter alarm shall be annunciated and shall flow back to UF permeate tank.

RO permeate water shall be collected in RO Permeate Tank. RO permeate from RO Permeate tank shall be used for HVAC requirement and transferred to HVAC water tank (UGT Tank) for distribution. Separate transmitter for RO permeate transfer pumps shall be provided for at low level in RO Permeate Tank in STP and at high level in HVAC water tank (UGT Tank) RO permeate transfer pumps shall trip.

RO unit shall have a CIP system. In CIP System. Level switch shall be installed. At low level, CIP Pump shall trip.

RO reject shall be routed to irrigation tank in STP from this tank irrigation water shall be transferred to Irrigation tank (UGT Tank) for distribution for landscape. Separate transmitter for Irrigation water transfer pumps shall be provided for at low level in Irrigation water Tank in STP and at high level in irrigation water tank (UGT Tank) Irrigation water transfer pumps shall trip.

7.0 STP – CIVIL/MSEP WORKS

The scope of work will consist of designing/sizing of basement in OSR area along with various units as per the list given below along with preparation and submission of civil GA, Structural and Fabrication Drawings.

All required design calculations will be submitted by the BIDDER along with the drawings for approval.

The various tanks/chambers needed to be constructed for the Sewage treatment system and their details are as follows-

The scope of work will consist of design, detailed engineering, construction, manufacture/procurement, supply erection and commissioning of various components as per the lists given subsequently in which the sizes, quantity are indicative only.

Contractor to design and provide the units and equipment as per their design. Preliminary Process Flow diagram is attached as part of tender drawings for reference.

7.1 Preliminary list of civil units and electro-mechanical equipment required for Sewage Treatment Plant, CTBD effluent treatment and RO is presented in Table 3, 4& Table 5.

Table 3: Preliminary List of Civil Units

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY	MOC
Units				
1	Screen Chamber	By Bidder	1	RCC
2	Oil & Grease Tank	Minimum 30 min HRT with Baffle walls	1	RCC
3	Equalisation tank	Capacity- Minimum 65 m3 (6 Hrs. HRT for design flow)	1	RCC
4	Anoxic tank	Suitable	2	RCC
5	Aeration Tank	Suitable	2	RCC
6	MBR Tank	Suitable	2	RCC
7	MBR Permeate Tank	Capacity- Minimum 22 m3 (2 Hrs HRT for design flow)	1	RCC
8	Sludge Holding Tank	Sludge storage minimum 24 hrs. according to sludge volume	1	RCC
9	MCC Room	Suitable	1	RCC
10	CTBD Collection Tank	Capacity- Minimum 12 m3 (4 Hrs. HRT for design flow)	1	RCC

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY	MOC
11	UF Feed Tank	Capacity- Minimum 6 m3 (2 Hrs. HRT for design flow)	1	RCC
12	MBR Permeate + CTBD UF permeate Tank/ RO Feed Tank	Capacity- Minimum 18 m3 (2 Hrs. HRT for design flow)	1	RCC
13	RO Permeate tank	Capacity- Minimum 10 m3 (2 Hrs. HRT for design flow)	1	RCC
14	RO Reject Tank	Capacity- Minimum 8 m3 (2 Hrs. HRT for design flow)	1	RCC

In addition, the following works shall be carried out by bidder

Table 4: Additional civil work requirements

SR. NO.	DESCRIPTION	SIZE/ CAPACITY	QTY./ NOS.	MOC
1	Construction of basement area for STP	As per bidder	As required. Detailed Design Engineering (DDE)	As per Tender specifications and approved by the PMC/ Client
2	Foundation of all pumps, blowers, tanks, skids and pipe work,	As per bidder	As required. DDE	As per Tender specifications and approved by the PMC/ Client
3	All drain trenches up to battery limit (Bidder's scope)	As per bidder	As required. DDE	As per Tender specifications and approved by the PMC / Client

SR. NO.	DESCRIPTION	SIZE/ CAPACITY	QTY./ NOS.	MOC
4.	Supports for electrical cables and pipes	As per bidder	As required. DDE	As per Tender specifications and approved by the PMC / Client
5.	MCC/PLC Room, Control Room, chemical storage area, etc. Including lighting within these rooms / shed	As per bidder	As required. DDE	As per Tender specifications and approved by the PMC / Client
6.	All required platforms, staircase, walkway, and cutouts for maintenance	As per bidder	As required. DDE	As per Tender specifications and approved by the PMC / Client
7.	Lighting in the basement area	As per bidder	As required. DDE	As per Tender specifications and approved by the PMC / Client

Table 5: Preliminary List of Electromechanical Equipment

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY.		MOC
			W	S	
A.	STP - 250KLD				
1.	Coarse Bar Screen	10 mm opening	1	-	SS
2.	Fine Bar Screen	6 mm opening	1	1	SS
3.	Slotted Pipe skimmer	Suitable	1	-	MSEP

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY.		MOC
			W	S	
4.	Equalized Sewage Transfer Pumps (Submersible type)	Minimum 6 m ³ /hr @ 15 m head submersible pumps to transfer equalized sewage from Equalisation Tank to Anoxic Tank (Cutter Type) Solid handling size minimum 20 mm.	2	1	CI with SS impeller
5.	Twin Lobe Rotary Air Blowers for Equalization Tank & Sludge Holding tank With Acoustic enclosure.	Air supply rate - 0.9 m ³ of air per m ³ of Volume of the tanks.	1	1	CI
6.	Air grid for Equalization tank & Sludge Holding Tank	Lot	1	-	UPVC
7.	Submersible mixers for anoxic tank	Suitable (1 No. for each tank)	2	-	SS
8.	Drum screen prior to anoxic tank	2 mm punched hole	2	-	MOC- Body- CS, Drum-SS 304
9.	Twin Lobe Rotary Air Blowers (VFD) for Aeration tanks With Acoustic Enclosure and VFD	As per design of bidder (Approximately 100 – 120 Nm ³ /hr)	2	1	CI
10.	Retrievable fine bubble diffuser membrane system for aeration tanks	As per design Air flow rate per diffuser- 8 m ³ /hr per diffuser	Lot	-	EPDM

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY.		MOC
			W	S	
11.	Nitrifying liquor transfer pumps/ Return sludge Pumps	Minimum 24 m ³ /hr and 12 m head, horizontal centrifugal pumps. Transferring mix liquor from MBR tank to Anoxic tank	2	1	CI with SS impeller
12.	Membrane Modules (Membrane Warranty shall be 5 years from the date of commissioning)	As per manufacturers design. Maximum Flux permitted- 25 LMH (1 Lot per tank)	2 Lot	-	
13.	MBR Permeate pumps (vacuum) with VFD	Minimum 6 m ³ /hr @ 15 m head, horizontal centrifugal pumps.	2	1	CI with SS impeller
14.	Back pulse pumps with VFD	As per manufacturers design	2	1	CI with SS impeller
15.	Twin Lobe Rotary Air Blowers (VFD) for MBR tanks With Acoustic Enclosure	As per Membrane Supplier	2	1	CI
16.	Centrifuge feed pumps	1.0 m ³ /hr @ 10 m head	1	1	CI with SS impeller
17.	Decanter Centrifuge	Suitable to handle 1 m ³ /hr sludge with 1% consistency. Outlet Consistency required =20%	1	-	Wetted parts SS
18.	NaOCl dosing tanks for CIP	As per Membrane manufacturers	1	-	HDPE

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY.		MOC
			W	S	
19.	NaOCl dosing pumps for CIP		1	1	1
20.	Citric acid dosing tanks for CIP		1		HDPE
21.	Citric tank agitator		1		SS
22.	Citric acid dosing pumps for CIP		1	1	PP
23.	NaOCl dosing tanks for Disinfection	Suitable (Common for treated sewage and CTBD effluent)	1	-	HDPE
24.	NaOCl dosing pumps for Disinfection	Suitable	1	1	PP
25.	Dewatering (DWPE) poly dosing tank	250 Litres	1	-	HDPE
26.	DWPE dosing agitator	Suitable	1	-	SS
27.	DWPE dosing pumps	Suitable	1	1	PP
28.	Chain-pulley block for submersible pumps	Suitable	1		
29.	Chain-pulley block 3 ton for Membrane Lifting	Suitable	1		
30.	MBR permeate transfer Pumps - for transferring MBR permeate to RO feed tank	5-8 m ³ /hr @ 10 m head horizontal centrifugal pumps.	1	1	CI with SS impeller

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY.		MOC
			W	S	
31.	Equalized Sewage bypass Pumps	13 m3/hr @ 35 m head	1	1	CI body SS impeller
B.	CTBD Effluent Treatment System-70 KLD				
1.	Filter Feed Pump	Minimum 4 m3/hr @ 25 m head, horizontal centrifugal pumps	1	1	CI with SS impeller
2.	NaOCl dosing pumps	Suitable	1	1	PP
3.	Pressure Sand Filter	By bidder, Filtration velocity 15 m/hr	1	0	MS-Epoxy
4.	Activated Carbon Filter	By bidder, Filtration velocity 12 m/hr Activated Carbon : Iodine Value:Min 900 mg	1	0	MS-Epoxy
5.	UF Feed Pump	As per membrane manufacturer requirements	1	1	CI with SS impeller
6.	Bag filter	Suitable	1	1	Bag- Polypropylene Housing- SS304
7.	Skid mounted UF system Membrane warranty shall be minimum 3 years from the date of commissioning.	Type of Membrane-Hollow Fibre Membrane pore size – <0.04Micron Recovery – 94-95% Flux : Max – 35-45 LMH	1 Lot		Skid-SS 304 Membrane - PVDF

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY.		MOC
			W	S	
8.	UF Backwash Pump (VFD Driven)	As per membrane manufacturer requirements	1	1	CI with SS impeller
9.	CEB Dosing System	Suitable with dosing tanks and pumps	1 lot		Tank – HDPE Agitator – SS 304 Pumps -PP
10.	CIP System	Suitable with dosing tanks and pumps	1 lot		Tank – HDPE Agitator – SS 304 Pumps -PP
C.	Reverse Osmosis System-200 KLD				
1.	RO feed pump	Minimum 10 m ³ /hr @ 25 m head, horizontal centrifugal pumps. Transferring water from UF permeate tank to MCF	1	1	CI with SS impeller
2.	Cartridge Filter for	Size -5 Micron	1 Lot	0	MOC of housing- PVC/ FRP MOC of cartridge - PP
3.	Antiscalant dosing system consisting of solution preparation tank with level indicator and level switches and with antiscalant dosing pumps-	Dosing Tank- 1 No. Dosing Pumps – 2 Nos. (1W+1S)	1 lot		Tank MOC- HDPE Dosing Pumps: PP

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY.		MOC
			W	S	
	electronic diaphragm type of suitable capacity and head				
4.	SMBS (Anti-oxidant) dosing system consisting of solution preparation tank with agitator, level indicator and level switches and with anti- oxidant dosing pumps electronic diaphragm type of suitable capacity and head	Dosing Tank- 1 No. Dosing Pumps – 2 Nos. (1W+1S)	1 lot		Tank MOC- HDPE Dosing Pumps: PP
5.	pH correction system	Dosing Tank- 1 No. Dosing Pumps – 2 Nos. (1W+1S)	1 lot		Tank MOC- HDPE Dosing Pumps: PP
6.	High pressure pump	Minimum 10 m ³ /hr and head as per membrane manufacturer RO projections	1	1	CI with SS impeller
7.	RO system	RO system with 10 m ³ /hr feed flow, complete with required no. of spiral wound RO membrane elements mounted in pressure vessels, all mounted on a skid. RO to be designed for min. 55% recovery and flux not exceeding 25 LMH. Instruments to include Flowmeter, pH and	1 Lot		Membrane MOC- PA thin film Pressure vessel MOC- FRP

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY.		MOC
			W	S	
		conductivity meter at RO inlet, pH and conductivity transmitter on the permeate outlet, flow meter on the permeate outlet, a flow indicator on the reject line, pressure switches on the high pressure pump suction and discharge, pressure gauge on the RO inlet and reject, ORP analyser on the inlet. The system should be designed for automatic operation with necessary interlocks. The membrane system must include membrane integrity test that is capable of demonstrating the membrane system is achieving a minimum of 4-log removal of particles greater than 2 microns. The membrane integrity test must be fully automated and capable of testing the membrane every 24 hours of operation. Each membrane module must have view glass for integrity test.			
8.	Cartridge Filter for CIP	Size -5 Micron	1 Lot	0	MOC of housing- PVC/ FRP

SR. NO.	UNIT / EQUIPMENT	CAPACITY / SIZES / DIMENSIONS	QTY.		MOC
			W	S	
					MOC of cartridge - PP
9.	CIP system for RO consisting of Cartridge filter, CIP tank with agitator, CIP pump, piping and hose pipes, flow indicator.	CIP Tank: 1 No. CIP pump 2 Nos, (1W+1S)	1 lot		Tank: HDPE Agitator : SS 304 CIP pump : SS 316 1 no. trolley MS with FRP coating

7.2 In addition to the above listed equipment, the following would be in the scope of the bidder:

SR. NO.	DESCRIPTION	SIZE/ CAPACITY	QTY. Nos.	MOC
A.	Interconnecting piping & Valves as required	By Bidder	1 Lot	MSEP for Pump suction and discharge, gravity sewage and sludge piping. Flexible Hose for Submersible pumps upto discharge header. GI for Air pipe above water and UPVC for

SR. NO.	DESCRIPTION	SIZE/ CAPACITY	QTY. Nos.	MOC
				submerged pipes and chemical dosing. High pressure piping - SS 316, Low pressure piping – uPVC
B.	ELECTRICAL WORK			
1.	MCC and PLC	By Bidder	1 Lot	As per tender specifications.
2.	Power cables from main STP Panel to all motors.	By Bidder	1 Lot	As per tender specifications.
3.	Push button stations near each motor.	By Bidder	1 Lot	As per tender specifications.
4.	Power / Control cables	By Bidder	1 Lot	As per tender specifications.
5.	Earthing	By Bidder	1 Lot	As per tender specifications.
6.	Separate KWhr Meter	By Bidder	1 Lot	As per tender specifications.
C.	INSTRUMENTS AS PER THE INDICATIVE LIST GIVEN BELOW :PLEASE REFER CONTROL PHILOSOPHY			
INDICATIVE LIST OF INSTRUMENTS FOR STP, CTRD, FTR and DO				
1.	Pressure Gauges – At the discharge of each pump &	By Bidder	1 Lot	As per tender specifications.

SR. NO.	DESCRIPTION	SIZE/ CAPACITY	QTY. Nos.	MOC
	Blowers, At the inlet and out let of PSF and outlet of ACF			
2.	Capacitance type Level Transmitters in Equalisation Tank, MBR Tank, MBR Permeate Tank, CTBD effluent collection Tank, UF Feed Tank, UF Permeate Tank/RO Feed Tank, Flushing water Tank, Irrigation Tank, RO permeate Tank, RO reject tank with provision for alarm at high level in the tank and alarm as well as tripping of pumps at low level.	By Bidder	1 Lot	As per tender specifications.
3.	Level switches in Sludge Holding Tank, all Dosing Tanks with provision for alarm at high level in the tank and alarm as well as tripping of pumps at low level.	By Bidder	1 Lot	As per tender specifications.

SR. NO.	DESCRIPTION	SIZE/ CAPACITY	QTY. Nos.	MOC
4.	DO meter in Aeration tanks	By Bidder	2 nos.	As per tender specifications
5.	Electro- magnetic Flow transmitter with indicator and totalizer – At the discharge of Equalized sewage transfer Pumps – At the discharge of Equalized sewage Bypass Pumps – At the discharge of MBR Permeate Pumps – At the discharge of MBR Backpulse Pumps – At the discharge of Filter Feed Pumps – At the discharge of	By Bidder	Lot	As per tender specifications

SR. NO.	DESCRIPTION	SIZE/ CAPACITY	QTY. Nos.	MOC
	UF feed Pumps – At the discharge of RO Feed Pumps – At the discharge of RO Permeate Line – Any location wherever necessary as per bidder's design			
6.	Pressure Transmitter at the discharge Backpulse Pumps	By Bidder	1 no.	As per tender specifications
7.	DPS across bag filter, Cartridge Filter, RO system	By Bidder	3 nos.	As per tender specifications
8.	Pressure switch at the suction & Discharge of RO High Pressure Pump	By Bidder	1 no.	As per tender specifications
9.	Turbidity meter on the discharge pipe of MBR Permeate Pumps and UF permeate pumps	By Bidder	3 nos.	As per tender specifications

SR. NO.	DESCRIPTION	SIZE/ CAPACITY	QTY. Nos.	MOC
10.	Flow Transmitter on Reject Line	By Bidder	1 no.	As per tender specifications
11.	pH Transmitter at discharge of RO Inlet and RO Permeate Line	By Bidder	As per requirement	As per tender specifications
12.	Conductivity Transmitter at RO Inlet and Permeate Line	By Bidder	2 nos.	As per tender specifications
13.	ORP analyser with transmitter and controller	By Bidder	1 nos.	As per tender specifications
14.	Dump valve & Auto valve for RO system	By Bidder	Lot	As per tender specifications
15.	If required, Instrument air compressor with an air receiver tank, air filter-dryer and air filter regulator along with instrument air piping and tubing for pneumatically operated valves	By Bidder	Lot	As per tender specifications
Note: 1. The Bidder should design and arrive at the sizing, capacities, MOC, type and other details of various equipment as listed above.				

SR. NO.	DESCRIPTION	SIZE/ CAPACITY	QTY. Nos.	MOC
2. The bidder is required to bring out the disparity/ ambiguity (if any) in the information mentioned herein before submission of the bid. The design philosophy mentioned is tentative and can be changed at the Bidder's end (with proper justification) to achieve the desired treated sewage characteristics. 3. For fully automation of MBR & UF-RO system, if any additional instruments are required contractor must provide the same.				

7.3 Following activities / items is also in the scope of the Bidder

- Foundation bolts for all equipment, puddle flanges, companion flanges with nuts, bolts, gaskets at terminal points.
- Final painting at site.
- Packing, forwarding, delivery to site, unloading at site.
- All consumables till the plant are handed over to the EMPLOYER/ENGINEER. Chemicals, Instruments, and equipment required for the installation and performance test should be arranged by Bidder.
- Provision of auxiliary steel/supporting steel for supporting the equipment and piping, Access platforms, ladder, handrail, and steel supporting base etc. common for all accessories as well as related drilling, welding work, painting of supports etc.
- All erection tools and tackles, cranes, hoisting equipment, etc as required.
- One (1) set of commissioning spares and maintenance tools.
- One (1) set of essential spares.
- Service water shall be made available by EMPLOYER/ENGINEER at one point of STP limit.

7.4 Erection and Commissioning Services

Following activities / items will be in the scope of the Bidder.

- Receiving material/ equipment at site, unloading all the equipment and material at site from carriages, checking against damages, storing in storage area provided by the EMPLOYER/ENGINEER, shall be in the in the scope of bidder.
- Movement of equipment and materials to erection at site by bidder.
- Suitable cutout shall be provided to facilitate smooth movement or replacement of equipment as and when required.
- Erection of all equipment and materials supplied under this contract.
- Grouting of equipment foundations.
- Hydro test and air leak test at site after completion of erection.

- Trial runs, testing, start-up, performance recalibration, commissioning and performance / Acceptance tests covered in the specification before handing over.
 - Proper tagging of all civil units, equipment should be done by Bidder.
 - The Bidder shall arrange following at his own cost.
-
- Adequate quantum of welding electrodes including special electrodes and welding units required for erection.
 - All consumable required for erection and commissioning.
 - All erection tools and tackles, cranes, hoisting equipment, etc as required.
 - All skilled, semi-skilled and unskilled labour required for erecting any facility, as required, for the labour force such as accommodation, transport, medical facility, insurance etc.
 - First fill of lubricants and grease etc.
 - Commissioning of the entire STP and accessories and handing over to EMPLOYER/ENGINEER.
 - Training of the STP facility management team for proper operation and maintenance.

7.5 Layout

Bidder should fit the entire STP, CTBD ETP and RO system within allocated area shown in the Layout. All supports for all equipment and platforms, walkways, stairways for all equipment as required are in bidder's scope and same shall be indicated in layout.

The interconnecting pipe shall be laid out in such a way that they are easily accessible for any maintenance or repair and also permits easy movement of the personnel. Easily accessible dismantling joints shall be provided for maintenance purposes.

The exact layout considering the actual equipment dimensions, handling facilities, clearances as required for easy operation and maintenance, pipe support locations etc shall have to be firmed up by the bidder for satisfactory operation of the systems covered under the scope of work.

The preliminary / proposed layout for STP is attached as part of tender drawing.

7.6 Piping Material Specification

All the material of construction of piping should be compatible with the requirement and as mentioned in Tender Specifications.

7.7 Painting

All surfaces such as light gauge / glasses, required for clear visual observation shall be cleaned after paint application.

Special care shall be taken to avoid any paints from dropping on the machined moving parts of equipment, name plates or indicator dials of instruments and control valves. Prior to paint application or spraying paint removable adhesive tape shall be used to cover these.

On final completion of all work, the BIDDER shall leave the entire premises within the site of his operation clean and free from all rubbish resulting from his painting operation and shall remove any paint or other blemishes caused by him on adjacent walls, windows, equipment and finished surface.

All piping shall be painted after hydro test only. The iron and steel surfaces shall be thoroughly cleaned of all rust, scale, grease or oil and then primer coat shall be applied.

The EMPLOYER/ENGINEER reserves the right to inspect the cleaning down and painting operations at any stage and if required by EMPLOYER/ENGINEER unsatisfactory surface preparation or paint application shall be remedied at BIDDER'S expense.

On job site, no painting shall be carried out in a dust laden atmosphere or under unsuitable weather conditions viz. when raining or when metal surfaces are damp or when condensation is likely to affect the paint film before it is dry.

All the exposed non-insulated carbon steel surfaces of equipment, piping and structural & auxiliary steel for pipe and equipment support shall be painted as indicated below:

- i. Surface preparation – removal of dust, dirt, oil, grease, scale and other foreign material by manual or power tools.
- ii. Primer – 2 coat of red oxide primer (conforming to IS: 2074) with minimum dry film thickness (DFT) 25 microns per coat.
- iii. Finish – 2 coat of synthetic enamel (conforming to IS: 2932) with minimum dry film thickness (DFT) 50 microns per coat.

7.8 Codes and Standards

All the equipment, systems and works covered under this specification shall comply with the relevant Indian Standards, regulations, and prevailing safety codes in the locality where the equipment will be installed. All the equipment shall comply in all respects with the requirements of latest edition of codes and standards.

In the event of any conflict between the codes and standards referred to in the specification and the requirements of this specification, the more stringent of this requirement shall govern.

7.9 Performance Test and Guarantees

The BIDDER/Contractor shall guarantee the outlet requirements of the STP system as specified in the tender and shall carry out performance guarantee tests upon successful commissioning for a minimum period of one month (1 month) continuous operation to prove the following performance guarantees (a) Throughout of the STP in m³/day as per the sewage availability (b) Treated Sewage, RO permeate and RO reject parameters compliance in normal and turndown conditions.

Quality of the Treated Sewage, RO permeate and RO reject at the outlet shall be as specified in "Table 2 -Design Basis" in these specifications, Analysis test reports from Third party NABL accredited laboratory shall be submitted (minimum twice a week) after the commissioning of the plant for a period of one month. (The quality requirement as specified above shall be confirmed by the BIDDER/Contractor).

Guaranteed power and chemical consumption of STP, CTBD ETP and RO system per day in kWh (as measured at a point before input into MCC). The BIDDER/Contractor shall guarantee the power/chemical consumption for the STP Plant in the prescribed format.

Power Consumption

Sl. No.	Equipment	Nos. Wkg.	Nos. Standby	kW (Rating)	I.kW (Input)	BkW	No. of Wkg. Hours	Total Power Consumption (Kwh)
1.								
2.								

Chemical Consumption and Power Requirement

Successful bidder has to indicate the Chemical consumption and the Power required for the plant in the following format.

Chemical Consumption

Sr.No.	Chemical	Consumption(g/m ³)	Kg/day
1.			
2.			

Successful bidder to furnish the above information for each equipment in the STP system.

In case the performance guarantee cannot be proved due to the reasons attributable to the BIDDER/Contractor, then the BIDDER/Contractor shall carry out the required

modifications/repairs/replacement to the plant at BIDDER's cost expeditiously and repeat the performance test runs until all specified guarantees are fully met.

The time period allowed for modifications/repairs/replacement of the STP system in the case as described in above shall be two months (60 days) from the date of commencement of performance tests.

The BIDDER/Contractor shall incorporate features including necessary instrumentation and controls to run the plant at lower loads and at the same time shall maintain the quality of Treated Sewage at the battery limit of STP as stipulated in this specification. The necessary arrangements required for loading the plant at lower loads shall be in the BIDDER/Contractor's scope of supply.

Uptime Guarantee

The contractor shall guarantee for the installed system an uptime of 98%. In case of shortfall in any month during the defect's liability period, the Defects Liability period shall get extended by a month for every month having shortfall and no reimbursement shall be made for the extended period.

7.10 Maintenance Requirements

In order to carry out preventive maintenance, it should be possible to readily disassemble, repair, and reassemble the equipment in the shortest period and to attend to any defect by a minimum disassembly.

The Bidder shall furnish one complete set of any special maintenance tools required for normal maintenance of equipment.

The Bidder shall confirm that space shown for the equipment is adequate from point of view of access, easy maintenance and for day-to-day operation.

Suitable cutout shall be provided to facilitate smooth movement or replacement of equipment as and when required.

All system must have convenient maintenance characteristics including:

- i. Care should be taken to cause minimum disturbance to production during preventive maintenance.
- ii. The bidder shall ensure easy access to replacement part, which can be installed by personnel of minimum skill.

7.11 Availability Requirements

All equipment and accessories shall be designed for maximum reliability and availability, particularly in respect of the following:

The equipment shall be of proven design, using materials established as appropriate to the service intended. Fabrication / manufacturing processes shall be subjected to quality surveillance and tests.

7.12 Noise and Vibration

Noise level produced by any equipment individually or collectively shall not exceed 85 dB (A) measured at a distance of 1.5 metres from the source in any direction.

The overall vibration level shall be as per zones A and B of ISO 10816-1. Vibration isolators shall be provided.

8.0 DATA TO BE FURNISHED BY CONTRACTOR AFTER AWARD OF CONTRACT

Minimum Drawing & Document Requirement

- A. Contractor shall furnish with quotation the drawings/data as marked (X) in the "With Quote". Quantity required is one per each quotation sent.
- B. Successful Contractor shall be required to furnish the minimum drawings/data as marked (X) within two weeks from date of order.
- C. For documents marked (X), 1 CD/pen drive (soft copy) and 5 hard copies shall be submitted for records and reference within one month before the shipment.

Sr. No.	Description of Drawings / Data Required	A	B	C
1.	Technical deviations & exceptions	X		
2.	Tender data sheets	X		
3.	Layout	X	X	X
4.	P&ID including specification of instrument control	X	X	X
5.	Process Flow Diagram indicating mass in/out from each unit in m ³ /h	X	X	X

Sr. No.	Description of Drawings / Data Required	A	B	C
6.	List of Units and Equipments including MOC, Sizes, Qty, etc.	X	X	X
7.	Deviation List	X	X	
8.	Exclusion List	X		
9.	Instrument list	X	X	X
10.	Technical specification sheet	X	X	X
11.	Instrument data sheets		X	X
12.	Motor list	X	X	X
13.	Utility consumption	X	X	X
14.	List of special tools with pricing		X	X
15.	List of Commissioning Spares	X		
16.	Recommended spare for 2 years parts with Pricing	X	X	X
17.	List of bought out items with names of Contractors	X	X	X
18.	Catalogues		X	X
19.	Quality control plan		X	X
20.	Time Schedule (Bar Chart)	X		
21.	Complete drawing list		X	X
22.	General arrangement drawing		X	X

Sr. No.	Description of Drawings / Data Required	A	B	C
23.	Structural (GFC) Drawings along with Design Calculations		X	X
24.	UF and RO projections		X	X
25.	Foundation & load details		X	X
26.	Cross sectional drawing with B.O.M.		X	X
27.	Component drawings		X	X
28.	Assembly/Erection drawings		X	X
29.	Design calculations		X	X
30.	Performance curves / tables		X	
31.	Piping drawings		X	
32.	GA of control panel		X	X
33.	Schematic wiring diagrams		X	X
34.	Cable schedule		X	X
35.	Interlock / alarm / trip schedule		X	X
36.	Control logic diagrams / written sequence		X	X
37.	Electrical layout		X	X
38.	Electrical layouts (Power, Earthing, Lighting, Lightning Protection, etc.)		X	X

Sr. No.	Description of Drawings / Data Required	A	B	C
39.	Single Line Diagrams, Control schemes, Interconnection Diagram/Schedule.		X	X
40.	Welding procedure		X	X
41.	Inspection test reports			X
42.	Material (mill) test reports			X
43.	Installation, operation & maintenance manuals			X
44.	Storage procedures		X	X
45.	Bill of material (for site receiving)		X	X
46.	Lubrication schedule		X	X
47.	O&M Manual			X

The Contractor shall ensure the following documentation are prepared and submitted to the PMC/ client for review, approval, and records as applicable.

Final Documents:

BIDDER shall submit the three copies of operation and maintenance manuals at the time of commissioning in addition to one copy two weeks before dispatch. The manual shall be in sufficient detail with step-by-step instructions to enable others to inspect erect, commission, maintain, dismantle, repair, reassemble and adjust all parts of the equipment. Each manual shall also include a complete set of approved as built drawings together with performance / rating curves / charts of the equipment, maintenance schedule and test certificates wherever applicable.

The BIDDER shall submit Quality assurance documentation specific for the project.

9.0 DELETED

ELECTRICAL SPECIFICATIONS

10.1 SCOPE

1.1 Scope of work shall include Design, Detail Engineering, supply, installation, carrying out stage-wise & shop floor inspections, testing and commissioning of all electrical equipment that are deemed necessary for the successful operation of the complete STP system including broadly the following items, but not limited to it: LT Motors, LPB (Local push button) stations, LT panels, JB's, power & control cabling system & its carrier system, earthing from equipment terminal to main conductor, civil support structures that are required for supporting the electrical equipment and services.

1.2 Bidder shall submit all drawings (covering the scope) to the Client/ Engineering Consultant for their review and approval and deliverables submission schedule furnished / mentioned at time to time after issue of LOI.

1.3 The electrical equipment supplied and installed by the contractor shall be compactable to connect with the Client's SCADA system. The numbers of input/output terminals required for the interconnectivity to SCADA shall be considered in adequate.

1.4 Whether called for specifically or not, all accessories required for normal operation of equipment are deemed to be considered as a part of the BIDDER's scope of supply. Any hardware required for mounting and installation of the above listed is within the scope of work.

1.5 The preparation of required earthing layout, cable tray layout equipment GA ,etc shall be in the scope of contractor.

1.6 Preparation of as-built drawings is in the scope of the contractor.

1.7 Supply of safety equipment for Electrical STP panel & other equipment, like rubber mat, danger board, etc. in the scope of STP contractor.

1.8 It is not the intent to specify completely herein, all details of design and construction of the equipment. However, the equipment shall conform in all respects to high standard of engineering, design and workmanship and be capable of performing in continuous commercial operation up to the BIDDER's guarantees in a manner acceptable to the PURCHASER, who will interpret the meaning of the drawings and specifications and shall be entitled to reject any work or material which is not in full accordance therewith.

10.2 MCC Panels

- The scope includes design, supply, testing, erection & commissioning of Motor Control Centre required for STP loads as per the scope matrix.
- The MCC shall be located inside the area allotted for STP.

- The following feeders will be provided by the purchasers, All further downstream distribution is in the scope of contractor.

Sl. No	Feeder Rating	Location	Purpose
	STP MAIN MCC		
1.	2x Nos. of 200A MCCB with electrical interlock	STP	Panel Incomer
2.	As per Equipment capacity & 20 % spare Feeders	STP	Panel Outgoing
	UF & RO PLANT MCC		
3.	2x Nos. of 160 A MCCB with electrical interlock	STP	Panel Incomer
4.	As per Equipment capacity & 20 % spare Feeders	STP	Panel Outgoing

- LT panel shall be metal clad, self standing dust proof construction, indoor cubicle type fitted with MCCB, fully draw-out type. Degree of protection of indoor LT panel shall be IP4X or better and outdoor panel shall be IP65, complying to form 4b.
- MCCBs rated up to 200A shall be provided with TMD release. From 250 A & above shall be microprocess Releases.
- For outgoing motor feeders rated upto 30kW shall be provided with MPCB. Motor rated upto 5.5kW DOL Starters shall be provided. Motors rated above 5.5kW shall be with star delta starter.
- The thermal overload protection relays to have built in protection against single phasing.
- All motor feeders shall be provided with Dial type ammeter.
- Control & monitoring shall be from STP controller. In addition, monitoring & metering shall also be done from remote SCADA thro redundant communication link between STP controller & SCADA using Modbus or other open protocol.
- The thickness of the load bearing members shall be 2 mm and the non load bearing members shall be 1.6mm.
- Electronic Multifunction meters (3 phase Current, 3 phase Voltage, KW, KWH, KVA, PF, Hz, KVAR) with 0.5 class accuracy shall be provided for all feeders with communication port.

Multifunction meters shall be EMC compliant, four quadrant type. Dual Source Energy meters should be considered.

- The bidder shall provide a minimum of 20% spare feeders per panel/ DB.
- 63A welding receptacles shall be provided in the STP area as per requirement. The contractor shall consider the required feeders in the STP MCC.
- 1 Nos of 40A MCCB LDB feeder & 6 Nos of 63A MCCB PDB feeders shall be provided by the STP contractor at STP MCC for STP pump house lighting & small power.
- The control supply required for the MCCs shall be derived from the bus itself thro control transformer.
- MCC shall meet the other requirements as specified in the enclosed technical specification and the corresponding Data Sheets attached.
- Potential free contacts has to be considered for remote monitoring.
- Selection of contactors & MPCB shall be TYPE 2 coordinated.

10.3 Motors

- The bidder scope of supply includes supply, erection, testing & commissioning of LT motors.
- The motor shall be energy efficient weather proof with degree of protection for the motor enclosure shall be IP-54 for indoor & IP55 for outdoor and terminal boxes shall be provided with at least IP-55. For multi core cable termination, gland plates shall be of non-magnetic material type.
- LT Motors shall meet the other requirements as specified in the enclosed Induction motor technical specification and the corresponding Data Sheets attached.
- All the LT motors shall be IE3 type efficiency.

10.4 Push Button Station

- For the purpose of control of the motors installed along with this package, the push button/control stations shall be installed near to the motors. Individual channel supports shall be used for each of the push button stations. These shall be installed as per approved erection detail drawing.
- All outdoor push button/control stations shall have necessary canopies. Wiring of push button control station shall be checked before giving control supply.

- The Local Push Button Station shall be furnished in cast Aluminium enclosure (minimum 2.0 mm thick) of weatherproof gasketed construction with dust and vermin proof suitable for outdoor use without canopy conforming to IPW-55 or better.
- The enclosures shall be suitable for mounting on column/wall and complete with push button, anodized aluminium inspection plate, earthing terminal and knockout for cable/conduit entry from top and bottom.
- Local start / stop push button stations lockable in stop position will be provided for all motors.

10.5 Earthing

- The scope includes the supply, laying & installation of earthing conductor around the STP building and connecting to the nearest earthing conductor for Motor, LPBS, MCC and any other equipment .
- STP contractor shall create the earthing grid at STP area and it will get connected to the main earthing grid. All connections between the main grid to STP equipment to be ensured by the contractor. Minimum two tap offs from main earthing loop will be taken near to the equipment and connected to the earthing conductor required for earthing the equipment. For all the equipment like motors, cable trays, tanks, earthing conductors shall be welded to the nearest available earth grid and connected to the equipment. A minimum of two leads are to be connected for the equipment.
- The following are earthing conductors shall be used by bidder for connecting equipment earthing leads to the main conductor. (Earthing conductor size will finalised as per the fault level calculation). Earthing will comply the IS 3043.

SL. NO.	DESCRIPTION	SIZE	MATERIAL	NO.OF LEADS (MIN)
1.1	415V, UPTO 11 KW	10 Sq.mm insulated wire	Cu	2
1.2	415V, 13 KW TO 30 KW	6 Sq.mm insulated wire	Cu	2
1.3	415V, 37 KW TO 67.5 KW	25 x 3 Sq.mm flat	GI	2
1.4	415V,	40 x4 Sq.mm flat	GI	2

SL. NO.	DESCRIPTION	SIZE	MATERIAL	NO.OF LEADS (MIN)
	75 KW & ABOVE			
1.5	MCC Panels	50 x 10 sq.mm flat	GI	2
1.6	Metallic Non Current Carrying Structures, Tanks, etc.	50 x 10 sq.mm flat	GI	2
1.7	Main earthing conductor	75 x 10 sq.mm flat	GI	2

10.6 Cables

- The Scope includes design, Engineering, supply, laying & installation of LT power & control cables required for STP system as per the scope matrix.
- The LT power cables shall be 1100V grade, single / multicore, stranded aluminium/copper conductor, XLPE insulated, with PVC inner sheath, armoured and outer sheath made of specially formulated FRLS PVC compound. Single core cables will have aluminium wire / formed wire armour, whereas multicore cables will have galvanised steel wire / formed wire armour. The cables will conform to IS-7098 - Part-I (1988) / IEC-502 (1983) in all respects. For Power cable laying, Installation & maintenance will confirm the IS 1255 Power cables upto 16Sq.mm shall be with copper conductor.
- The LT control cables shall be 1100V grade, multicore, 2.5 sq.mm cross section, stranded copper conductor having 7 strands, PVC insulated, inner PVC sheathed, galvanised steel wire/formed wire armoured and outer sheath made of FRLS PVC compound conforming to the performance requirements outlined above will be used. The cables will conform to IS:1554 (Part-I) - 1988 / IEC-502 (1983) in all other respects.
- LT Power & control cables shall meet the other requirements as specified in the enclosed document and the corresponding Data Sheets attached.
- The cables should be sized in such a way that the voltage drop in cables between MCC to the motor terminals for full load motor current shall be limited to 1% and the voltage dip during motor starting shall be limited to less than 15%. The cable size is also taken care of D-rating factor & inrush current of motor. The bidder should furnish the cable sizing document for purchasers/ consultant approval.

- The cable glands and lugs shall be of Nickel Plated brass double compression glands.
- The scope shall also includes supply & installation of Lugs & glands, cable jointing kits for both the power & control cables installed under this scope of work.

10.7 Cable Carrier System

- The scope shall include supply, laying & installation of cable carrier system along with supports and accessories as per the scope matrix.
- Cable carrier system shall be designed such that in no location along the route of cable tray, the loading is greater than 75%.
- The cable trays shall be prefabricated ladder type/Perforated type galvanised iron trays. Separate cable trays will be used for, 415 V power and control cables. The arrangement of trays shall be Low voltage trays in 1st tier, electrical control trays in 2nd tier and instrumentation trays in 3rd tier.
- Cable bending will confirm the IS 1255 as according to that cable tray size shall be select.
- All cable trays shall be of ladder type/perforated type construction of various sizes with accessories. There shall be a maximum spacing of 1500 mm between cable tray supports, except fittings (elbows, tees, etc.) This shall be supported at each splice.
- The flange height of the cable tray shall be 100MM for all the trays.
- 150MM,300MM,450MM,600MM,750MM width cable trays shall be used.
- Single core cable shall be laid in trefoil arrangement.

10.8 Approved Vendor List

Bidder shall strictly adhere to the list of vendors indicated in the vendor list for procuring any items.

10.9 As Built Drawings

The successful bidder shall submit the as built drawings to engineering design consultant for approval.

**10.0 TECHNICAL SPECIFICATIONS FOR MECHANICAL EQUIPMENT AND COMPONENTS
FOR SEWAGE TREATMENT PLANT****General Unit Operations**

Upon completion, all equipment and materials shall be cleaned, tested for static performance, and signed off by the Employer/PMC.

All the equipment shall be issued in catalogue form, together with working drawings for builders work, layout arrangement, electrical control arrangements.

Prior to equipment being ordered and work starting, approval in writing shall be issued by the Employer/PMC.

Tenderer shall furnish proof to the satisfaction of the Employer that the plant equipment supplier shall be reputed one with good credentials in similar application and have a local qualified and experienced field servicing engineer who can furnish adequate servicing facilities to the owner and operator during normal operation and emergency.

All the equipment shall be provided with warrantee of 1 year after commissioning of project or 18 months after the erection of equipment. The equipment, pipes and valves shall be factory tested in terms of performance, Vibration, leakage, hydrostatic testing and given parameters/criteria in accordance with approved datasheet and QAP of respective equipment.

Oil & Grease Removal Unit:

Oil & Grease Removal unit shall be made of civil construction. Slotted pipe skimming provision shall be provided to remove the oil and grease from the tank surface and suitable mechanism shall be provided to collect the scum/grease for further treatment and safe disposal. The MOC of the skimmer shall be MSEP.

Submersible Sewage Pumps:

Submersible pump, with appropriate flow rate and head shall be installed as per Schematic Process Flow Diagram. The submersible pumps shall be used at Equalization tank.

Pumps shall be suitable for pumping grossly polluted raw sewage containing hairs, fibrous materials, coarse solids and tough plastic materials, free from clogging and catching. Solid handling capacity up to 30 mm.

Pumps shall be tested in accordance with ISO 9906.

Pump casing shall be of high grade cast iron, impeller shall be SS and shaft shall be of stainless steel. Double Mechanical Seals shall be provided. The entire pump assembly shall be adequately protected from corrosion. Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 40000 hours of working. Bearings shall be grease lubricated or non-grease type.

Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 m at sites. Vibration levels shall not exceed the levels given in BS 4675.

Pump flange shall be suitable for automatic coupling to discharge pedestal with single guide rail of stainless steel. Motor shall be of submersible type, insulated against heat and humidity to Class “F” with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply with permissible speed not exceeding 1500rpm. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer.

Duck foot discharge connection, stainless steel (AISI 304) lifting chain with stainless steel (AISI 304) guide bar, stainless steel hooks for chains shall be provided so that pump can be automatically connected to the discharge pipe work. One set of operating valve and non-return valve shall be provided at the discharge pipe of each pump in case the pumps share the common discharge line or outlet point is submersed in water. All necessary accessories for fixing such as bolts, nuts, washers, etc. shall be included. Detailed of fixing to pump shall be submitted to the Consultant for approval.

The operation of pumps shall be controlled by level transmitters. All the pumps shall be able to operate as the duty pump. The standby pump shall be arranged to start automatically on failure of the duty pump and the electricity supply to the failed unit shall be cut off. The switch gear shall be suitable for automatic operation with manual override. The pump shall be designed to have pump starts less than 10 times per hour.

Rotary Drum Screen

The rotary drum screen, with screen opening of 2 mm, shall be provided before the MBR module. It shall consist of screen, a screw conveyor and compactor.

During operation, solids within the incoming flow shall enter into the drum screen and progressively collect into the screen mesh. The upstream water level shall rise and at a predetermined level, the drum screen and screw conveyor shall activate and rotate immersing a clean section of the screen into the effluent.

During rotation the solids or screenings shall become inverted and then fall into the screw conveyor. Spray nozzles and a roller brush shall be fixed to the periphery of the drum screen to clean away any residual solids from the mesh.

The material of construction shall be SS316. The screen shall be easy to install.

Membrane Bio-Reactor

Equalised Sewage from Equalisation tank via fine screen shall enter in to Anoxic tanks. From anoxic zone mixed liquor shall be conveyed to aeration Tanks, where air (with fine bubble diffused aeration system) is supplied to provide oxygen for carbonaceous BOD removal and nitrification (ammonia conversion to nitrates).

The Membrane (ultra-filtration) Filtration process shall comprise of the following unit processes and services:

Bidder may consider Membrane type of;

Hollow fibre membrane

General arrangement of the Works;

- Outside-in submerged arrangement for Membranes
- Membrane flux maximum 25 litres/m²/hr during average day (design) flow conditions.
- Back-pulsing as per system requirement
- Membrane Filtration Cartridges
- Membrane Cartridge Cassettes
- Air Distribution Piping
- Air Blower Equipment
- Internal Recycle Pumping Equipment
- CIP Equipment and Instrumentation
- Automated Pneumatic Valves
- Process Instrumentation
- PLC System
- Process Tankage (as applicable)
- Pressure Membrane Filtration System (include backwash & permeate pumps, clean-in-place system, pressure measurement, membrane air scour and other ancillary equipment)
- Membrane shall comprise of homogeneous hollow fibre type with nominal pore size in the range of 0.01 to 0.05 µm.
- Membrane material and components to be chlorine resistant and membrane material shall be of PVDF and shall be reinforced type.
- Membrane backwash system shall use a filtrate backwash together with external air scour to remove accumulated particles and maintain a design filtrate production rate.
- In-situ chemical cleanings (maintenance or recovery cleaning) shall be considered to maintain the membrane TMP.
- Chemical enhanced backwash shall be provided to maintain membrane permeability.
- The membrane system must include membrane integrity test that is capable of demonstrating the membrane system is achieving a minimum of 4-log removal of particles greater than 3 microns. The membrane integrity test must be fully automated and capable of testing the membrane every 24 hours of operation. In addition, the bidder shall provide an appropriate test method to locate a single faulty fibre within the array of membrane modules in housing units.
- All unit operations within a membrane system shall be fully automated and suitable for unattended operation including but not limited to backwash, chemical enhanced backwash, membrane integrity monitoring and clean-in-place (CIP) sequence.
- The membrane supporting frames shall be SS304.

End Suction Pump

End suction centrifugal pump, with appropriate flow rate and head shall be installed as per process requirements. The End suction pumps shall be used as nitrifying liquor transfer/ RAS pump, MBR permeate pump, Back upse pump, CIP Pumps, Filter feed pumps, UF feed Pumps, RO feed pumps, Centrifuge feed pumps, Permeate transfer pump, Irrigation water transfer pumps, flushing water transfer pumps, HVAC water transfer pumps etc.

End suction pumps shall be horizontally mounted complete with drive motor on a common base plate. The pump/drive coupling shall be of the spacer type to facilitate removal of the pump rotating element and bearing housing without dismantling the pump casing, adjoining pipe work or drive motor.

Pumps shall be tested in accordance with ISO 9906.

Pump casing shall be of high grade cast iron, impeller shall be SS and shaft shall be of stainless steel. Mechanical Seals shall be provided. The entire pump assembly shall be adequately protected from corrosion. Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 40000 hours of working. Bearings shall be grease lubricated or non-grease type.

Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 M at sites. Vibration levels shall not exceed the levels given in BS 4675.

The dimensions of the pump shall be metric conforming to BS 5257 or its equivalent standard. Flanges shall conform to BS EN 1092-1/ BS 4504.

The bedplate shall be of substantial fabricated steel construction with floor fixing bolt holes ready drilled. All holding down bolts etc. shall be supplied with the units.

The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.

Impellers shall be provided with means to prevent abrasive matter reaching the glands and with fully shrouded impellers, to prevent the trapping of matter between the impeller vanes and the casing.

Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class "F" with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer. Pumps shall be provided with VFD drives as mentioned in the specifications.

Flushing facilities shall be provided for mechanical seals where pump fluid may be contaminated with abrasive material.

Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

The pumps and associated pipe work shall be, wherever possible, arranged so that air can be completely expelled during priming. Where this is not possible, facilities shall be provided for the removal of the trapped air. Adequate facilities shall be provided for drainage of the pumps for inspection purposes.

Tappings shall be provided at both the suction and discharge flanges for pressure gauge equipment.

Air Blowers

General

- a) Blowers shall be of the rotary tri or twin lobe positive displacement type, each provided with inlet filter and silencer, pressure reducing valve, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend or silencer in the delivery branch. Bearing housings and gear boxes shall be separated from the blower housings by air spaces. The units shall be complete with a self-contained oil cooling system for the bearings. The noise level shall not exceed 85 dBA at 1 meter from the Blower. Vibration levels shall not exceed the levels given in BS 4675. Suitable lifting arrangement shall be provided for easy handling of blowers in the event of installation or maintenance.
- b) Blowers shall be installed for aeration at Equalization tank & Sludge Holding Tank and Aeration / MBBR Tank. All blowers shall be of appropriate flow rate and pressure as per Process requirement. The blowers for equalization tank and Aeration Tank shall be of continuous duty. For every eight hours blowers operation, the blowers shall be interchanging automatically for equal operation hours.
- c) The blowers shall be rated to deliver required quantity of oil free air at the design pressure while operating at not more than 1500 rpm. The blower shall be driven by a squirrel cage induction motor selected for 125% of the power absorbed at the rated discharge and pressure. The drive shall be with multiple V belts or suitable inline coupling and shall be protected through a suitable guard. The air blowers should have acoustic enclosure & with anti-vibration pads.
- d) The bearings shall be generously designed to give long operational life. Bearings at the drive end may be oil or grease lubricated. The gears and bearings at the non-drive end shall be oil lubricated. Bearings shall be provided with oil throwers to prevent leakage of oil. The bearings shall have a minimum working life of 40000 hours of working. The blower shall be arranged for horizontal inlet and vertical outlet, delivery velocity not exceeding 25 m/s and each blower shall be provided with following components but not limited to:
 - (1) Common base frame for Blower & Motor.
 - (2) Inlet silencer and filter.
 - (3) Discharge Silencer & non-return valve in delivery branch.
 - (4) Screwed end metallic Ball valves in both inlet and delivery branches with metal-to-metal sealing.
 - (5) Pressure relief valve or excess pressure safety device.
 - (6) Bellows type couplings on inlet and delivery branches.

- (7) Acoustics Enclosure.
 - (8) Isolating valves, Pressure reducing valves & Pressure gauges.
 - (9) Air Flow meters, Temperature gauges.
 - (10) Water trap.
- e) The interconnecting pipe work shall be flanged to BS EN 1092-1/BS: 4504. A drain cock shall be provided at the lowest point in each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.
 - f) Each blower shall contain one inlet air pressure, one discharge air pressure, and one discharge air temperature gauge. The pressure gauges shall be calibrated in kPa absolute and be of the compound type. The gauges shall have circular dials, minimum 100 mm diameter with black figures on white background. Pressure gauges shall be furnished with pulsation damper. Temperature gauges shall be manufactured with standard temperature bulb.
 - g) Air Blower Motors shall be EFF-2 Energy Efficient type. Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class “F” with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply. Electrical cable of sufficient length which shall be waterproofed shall be supplied by Blower manufacturer. Process Aeration Tank Blowers Motors shall be provided with VFD.
 - h) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of both fine and coarse bubble diffuser.

Accessories

- a) Inlet filter and silencer :

Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet of the Blower via a flexible connection. Such mounting is for the purpose of reducing pressure drop across the inlet appurtenances and of minimizing noise from pipes. Filter/silencer housing shall consist of galvanized steel plate and acoustical sound-deadening material on the inside.

Filters shall be removable through easily accessible doors and have very high removal efficiency and shall be sized for maximum face of velocity of 2m/sec at peak air flow.

- b) Discharge Flex Connector:

Each blower shall be provided with discharge expansion joint. The expansion joint shall alleviate stress caused by thermal expansion and contraction in the piping system. The expansion joints shall be capable of withstanding the pressure under all operating conditions and shall be rated for temperatures up to 160°C.

c) Discharge Cone Diffuser Silencer:

Each blower shall be supplied with a combined discharge cone diffuser-silencer to increase the discharge from the blower outlet to the discharge pipe, thus reducing the air velocity to max. 20 m/sec. The length of the discharge cone shall be aerodynamically designed in order to recover dynamic pressure head and minimize discharge turbulence. The discharge cone shall be constructed of galvanized steel plate and acoustical sound-deadening material on the inside, with flanges, and be equipped with a stud for a possible measuring device.

d) Blow-off (Bypass) Valve:

Each blower shall be provided with a blow-off valve to allow unloaded start-up and unloaded stop. The valve shall be a Screwed end metallic ball valve, for air service.

Blow-off silencer shall be provided for each blower and mounted on the discharge by-pass line. The blow-off valve silencer shall be constructed of galvanized steel and contain sound absorption material encased in an outer shell. The silencer shall have one sleeve inlet connection for mounting onto the end of the bypass line.

e) Discharge check valve (Back-flow Barrier):

Each blower shall be provided with one discharge check valve located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1/ BS 4504. The pressure losses of the fully open valve must not exceed 1.0 kPa. The valves shall be rated for temperatures up to 160°C.

f) Base plate and anchor bolts:

Each blower unit shall be furnished with a frame of adequate size to support the blower, motor, magnetic bearing controller frequency converter, control cabinet and other accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting by a fork-lift, with all equipment mounted, without distortion or other damage to the base plate or to components parts of the machinery.

Material of Construction:

Sl. No.	Part Description	Material of Construction
A	Blower Housing	Cast Iron
B	Lobe	Cast Iron
C	Shaft	Carbon steel (high tensile)

Sl. No.	Part Description	Material of Construction
D	Acoustic enclosure	As per BOQ
E	All connecting accessories and anchor bolts	AISI 316

Performance Guarantee

The Performance of the blowers shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%. Blower or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

Fine Bubble Membrane Diffusers

Provide a removable header arrangement (Retrievable Type) that provides complete mixing of aeration basin contents.

Space diffusers evenly along each header to provide full floor coverage.

Furnish all components necessary to provide a complete mixing system within each Aeration Tank. Work shall include but not necessarily be limited to the following:

- Flanged connections at the upstream side of each drop leg for connection to an isolation butterfly valve.
- SS 316 Drop legs.
- Slip joint connections to the air distribution header
- Air distribution headers.
- Diffuser connectors.
- Diffusers (tubular) in EPDM with PTFE coating.
- Anchored Supports (SS 316)
- Gaskets.
- Header joints (CPVC).
- Bolts, nuts, and washers (SS 316).

- Space diffusers evenly along the air headers.
- Provide two tubular diffusers at each header connection. Mount to a reinforced tee located on the bottom center line of the header. The reinforced Tee shall be adjustable to allow accurate alignment of the diffuser.
- The Diffusers should be able to withstand high blower air and water temperature.

Diffuser Assembly

- Field Oxygen transfer efficiency: minimum 18.0 %.
- Non-clog, tubular design with inverted air reservoir.
- Bottom deflector to prevent debris from entering diffuser assembly.
- Full profile end caps to prevent air blow off.
- Minimum length: 1000 mm.
- Installation pitch: 100 -600 mm.
- Provide orifice flow control to ensure orifice head loss is at least 2.5 times the head loss in the air header at all air flow rates in the diffuser's design operating range.
- Space diffusers along air header to provide uniform mixing of the aeration tank contents.

Air Header and Drop-legs

- Header shall be GI-Class C and drop legs submerged in water shall be UPVC.
- Fabricate air distribution header in sections up to a maximum of 12 meters in length.
- Bottom elevation of the air distribution header shall be same throughout the tank.
- Provide removable end cap at header ends.
- Design connections between sections of the air distribution header to allow individual header sections to rotate independently of adjacent header sections.
- Remove all discoloration and deposits left by welding by pickling.
- Factory weld all diffuser connections. Stiffen both the diffuser connectors and the headers to withstand a moment of 56.5 N.m at the connector without permanent deformation.

Supports and Anchors

- Provide wall and floor mounting supports for all drop legs and air headers as necessary to anchor firmly on the wall and to the bottom of the tank and as specified herein.
- Anchor supports to concrete walls and floors using stainless steel expansion bolts sized and spaced as required for the loads encountered.
- Design supports to allow levelling the air header and diffuser assemblies to within specified tolerances.
- Provide expansion couplings in the drop legs and air headers as necessary to accommodate anticipated thermal expansion and contraction.
- The raw wastewater temperature is expected to vary between 20 and 35 degrees Centigrade.
- The ambient air temperature is expected to vary between 20 and 36 degrees Centigrade.
- The aeration air will be compressed to a pressure of approximately 0.55 bar.
- Submit expansion coupling design as well as computations for sizing.

Spare Parts

Provide spare parts in the quantities indicated.

Item	Quantity
Diffuser Assemblies	10%

Installation

- Install all components in accordance with the manufacturer's instructions and recommendations.
- Install all diffusers to within +/- 10 mm of a common horizontal plane.

Field testing

- All Fine bubble diffused aeration systems will be field tested.
- Testing will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.
- Levelling tests:

- i. Introduce clear water into each tank to the top of the diffuser elements.
- ii. Check the level of the diffusers to document that all element horizontal surfaces are within 10 mm of a common horizontal plane and at the specified elevation.

Leakage and distribution of flow tests:

- After successful completion of the levelling tests, raise the water level to 50mm above the manifold.
- Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.
- Pressure test:
 - All of air supply pipe line shall be tested by pressure. Test pressure shall be at least 2 times higher than normal operation pressure.
 - If client is unsatisfied any test result, repeat the test until the installation is essentially void of air leaks.
 - Repair any leaks in the element's holders, elements, pipes or the like.

Submersible Mixer**Propeller**

The propeller shall be of the cast marine type or welded type of material SS 304. For a welded propeller, only full penetration welds are acceptable. The propeller shall be checked thoroughly for welding defects, especially at the blade root, where stresses are at a maximum.

The propeller shall be locked to the shaft. Positive fixing of the propeller to the shaft may be achieved by a taper-to-taper, side fitting key and a corrosion resistant impeller retainer cone with cap screw. Keys shall not be allowed if clad shaft material is used.

All propellers shall be statically and dynamically balanced in air as well as hydraulically balanced to ensure vibration free operation and optimum cavitation's free conditions and to promote maximum pumping rate and entrainment for any given power.

Shaft

The shaft shall be designed to be stiff and shall be machined from solid bar. It shall be a one-piece component, without intermediate couplings. The first critical speed shall be not less than 2.5 times the operating speed.

Mechanical Seal

A mechanical seal shall be applied for sealing the mixer shaft.

The primary seal shall be a replaceable cartridge mechanical seal. The seal shall be an inside seal of fire-resistant construction and a balanced design.

The mechanical seal shall have a provision for venting the seal chamber to ensure that it is completely filled with liquid prior to start-up. A back-up bushing of non-sparking material having a small clearance shall be provided in the flange or housing in order to restrict the product leakage rate in the event of a mechanical seal failure.

Bearings

Mixers shall be provided with oil or grease lubricated bearings. All bearings, including those of the motor and gearbox, if fitted, shall be either of the anti-friction or hydrodynamic type and shall have a minimum L-10 rating life of 40 000 hours in continuous operation at rated mixing conditions.

Lifting arrangement

The mixer shall be supported by the lifting chain from a hanging point and have a sliding guide bracket of stainless steel Grade 316 S316 to BS 970-1 (partially replaced by BS EN 10084) mounted on a vertical guide rail. It shall be possible to remove and replace the mixer safely without lowering the level in the sump or leaning into or entering the sump. The guide rail and hanging arrangement shall permit full adjustment of the depth and direction of the mixer. The guide system shall be retained at the lower end and upper end by stainless steel mounting brackets. Rails shall be installed to within ± 0.5 mm/m length of the vertical with no more than +1 mm -0 mm tolerance between parallel rails.

Chemical Dosing Pumps

Mechanical diaphragm type positive displacement pumps for dosing shall be provided for

- a. Citric Acid Dosing for MBR Cleaning
- b. NaOCl dosing system for MBR Cleaning
- c. NaOCl dosing system for disinfection
- d. CEB Dosing system for UF
- e. CIP Dosing system for UF
- f. RO chemicals dosing system
- g. Polyelectrolyte dosing system for sludge dewatering

Chemical dosing pumps shall be piston, piston diaphragm or mechanical diaphragm type as specified. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined base plate.

Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self-cleaning action. Ball and seat materials shall be resistant to abrasion.

Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving stepless adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene. Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief with a set point of 110% of system maximum working pressure and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.

The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected. Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

Flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gear box shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.

Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class "F" with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply with permissible speed not exceeding 1500rpm.

Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer.

All dosing pumps shall have facility/terminals for pulse input & output (4-20 mA) to facilitate online control via plant PLC.

Dosing Tank and Mixer

General

Dewatering Polymer, Citric acid, UF & RO chemicals tank shall have 1 no. of mixer per tank; this tank shall be used to dissolve the Dewatering polymer, citric acid, UF & RO chemicals to required concentration. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, level transmitters, direct reading level gauge, ladder, air exhaust pipe etc. However, for the NaOCl the required concentration shall be directly prepared in separate tank and no mechanical mixers are required for NaOCl tanks.

(i) Fabrication

- a) The tank shall be made of corrosion resistant material (HDPE)
- b) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.
- c) The tank shall be provided with necessary mounting seats for overflow pipe, etc.
- d) The motor-driven mixer shall be vertical speed reducer, direct-coupled type of 2-stage propeller type, as a rule and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the center or at a position off the center according as the tank being rectangular or circular.
- e) The mixer shall be protected by electrical prevention of dry operation.
- f) The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.

(ii) Materials

- a) Main Tank body : HDPE
- b) Mixer frame : SS 304
- c) Mixer shaft : SS 304
- d) Blade : SS 304

(iii) Accessories (per Unit)

- a) Foundation bolt and nut 1 set
- b) Air vent pipe 1 set
- c) Mixer 1 unit
- d) Direct reading level gauge 1 unit

Filters (Pressure Sand Filter and Activated Carbon Filter)

Pressure Sand Filter and Activated Carbon Filter shall be of vertical type. The surface flow rate for both the filters should not be more than 12 m³/m²/hr. Vessels shall be designed as per IS 2825 Class II, the Filter Shell and dish End shall comprise a mild steel IS 2062. Electrically welded shell complete with nozzles and nozzles plates internal distribution and draw-off through, faced pads for inlet, outlet, wash-in, drain, adequate sized access manholes /handholes, filter supporting feet, necessary filtering media and sundry accessories. Shell shall be treated internally with an approved anti-corrosion coating (Polyurethane), and externally with primer and under coat prior to application of two coats of finishing paint of food grade quality of approved colour with Total DFT 250 microns. Corrosion allowance of 3 mm shall be considered thickness of the shell and Dish End and 1mm thinning allowance for Dish Ends. Full GA and design details shall be submitted at time of tendering for acceptance.

Filters shall be equipped with bulk air release valves, backwash water sight glasses, inlet and outlet pressure gauges, drain pipe and valves, draw-off cocks for taking samples of raw and filtered water and can be manually washed. Air release valve shall be manual ball valve with one manual isolation valve. Filter bed shall consist of at least two but preferably more layers of filter media, each having a different particle size properly supported by suitable under drain. Where nozzles are provided as a form of under-drain, they shall be completely manufactured from poly-propylene screwed into a high quality heavy gauge steel plate and do not have any metal screws or holding bolts.

Filter vessels shall be welded and tested by the manufacturer before shipment. Finished filter vessels shall be subjected to a pressure test of not less than 7.0 Bar or twice the actual working pressure whichever the greater.

The filter shall be designed to withstand chemicals and necessary filtering media and sundry accessories. The filter shall also be equipped with air release valve, water control valves, wash water sight glasses, inlet and outlet pressure gauges and draw-off cocks for taking sample of raw and filtered water. The filter operation shall be manual.

Filter media shall consist of adequate 6.4mm to 2.5mm double washed and graded pebbles and double washed and graded filter sand to 16/30 B.S. sieve size. Filter media for Pressure

Sand Filter shall confirm to AWWA B100 and Activated Carbon Filter shall confirm to AWWA B604. Iodine value of activated carbon shall be as per approved make.

Filters may be selected at a maximum filtration rate should not be more than 12 m³/m²/hr provided that it complies with manufacturer's recommendation and gives operation to the satisfaction of the Employer/Consultants. Backwashing of the filter shall be manual. Filter backwash shall be directed as indicated in the specifications.

Ultrafiltration System

Ultra-filtration system shall comprise of the following processes and services:

- a) The ultrafiltration system shall be designed for average flow.
- b) Low pressure Membrane Filtration System (include UF feed pumps, backwash, clean-in-place system, CEB system, pressure measurement, and other ancillary equipment).
- c) Membrane System shall be pressure driven.
- d) Membrane shall be comprising of homogeneous hollow fibre type with nominal pore size of 0.04 µm for removal of bacteria, viruses, and particulates including colloids.
- e) Hollow fibres Membrane with four Connections in each module.
- f) UF Membrane shall be Provided with all necessary chemical cleaning facility like CIP System and CEB System with air scouring facility as per vendor requirement.

Typical parameters of UF System

- a) Normal Operating Pressure: 2.5 kg/cm².
- b) Maximum Allowable Pressure: 5 kg/cm².
- c) Trans Membrane Pressure: 1.5-2.0 kg/cm².
- d) Average Flux Rate shall not exceed 35-45 LMH.
- e) Operating pH range 2-11.
- f) The hollow fiber membranes to be made from PVDF polymer or poly sulfone with minimum 3 years warranty.
- g) MOC of End Caps shall be GRP.
- h) MOC of central permeate tube, feed & reject port shall be UPVC.
- i) MOC of Membrane housing shall be U-PVC or FRP.

- j) Membrane backwash system shall use a filtrate backwash together with external air scour (if required) to remove accumulated particles and maintain a design filtrate production rate. Chemical enhanced backwash shall use dilute hypochlorite acid for a short period of time to maintain membrane permeability.
- k) The membrane system must include membrane integrity test that is capable of demonstrating the membrane system is achieving a minimum of 4-log removal of particles greater than 2 microns. The membrane integrity test must be fully automated and capable of testing the membrane every 24 hours of operation. Each membrane module must have view glass for integrity test.
- l) All unit operations within a membrane system shall be fully automated and suitable for unattended operation including but not limited to backwash, chemical enhanced backwash, membrane integrity monitoring and clean-in-place (CIP) sequence. Vendor must provide membrane repairing kit.

Reverse Osmosis System

Reverse Osmosis (RO) system shall comprise of the following processes and services:

- a) The RO system shall be designed for average flow.
- b) RO membranes shall be Spiral wound
- c) Dimensions of membrane shall be suitable
- d) Membrane shall be of Thin film composite polyether sulfone / Polysulfone membrane for brackish water services having following stability characteristics and with minimum life of 3 years under stated operating feed conditions.
- e) Stability Characteristics:
- f) Chlorine stability: Minimum of 1000 ppm-hr free chlorine for doubling the salt passage
- g) pH stability: 2-11 (Continuous) ; 1-12 (Short-term)
- h) Thermal stability: Upto 450C
- i) Mechanical stability: 1000 psi (7.0 MPa)
- j) Average Flux Rate shall not exceed 25 LMH.
- k) System should be provided with victaulic coupling.

Centrifuge

The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.

The bowl and scroll shall be made from stainless steel AISI 316 material. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard-coated material.

The whole rotating assembly shall be enclosed by a Stainless steel (AISI316) fabricated casing incorporating a Centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.

The rotor shall consist of a solid bowl which is conical-cylindrical in shape and which rotates about a central shaft. An inner scroll shall be provided to convey separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.

The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced and test certificates provided.

Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.

The bowl shall be provided with an adjustable 360° peripheral weir at its cylindrical end to control the depth of the Centrate in the rotor.

The fixed outlet castings of the rotor shall be designed to collect the centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.

The centrifuge shall be mounted on heavy-duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp vibrations and prevent vibration transmission. Two axis vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.

Provide a factory assembled acoustical enclosure around the entire centrifuge assembly. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all centrifuge parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel.

The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

Flexible connections shall be provided on the sludge fed system and the Centrate system at the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

- **Variable Speed Drive**

A variable speed drive shall be provided to accelerate the rotor to operational speed and maintain that speed during the centrifuge's duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple 'V' notch belt drive.

- **Differential Scroll Drive**

The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed to the outer bowl. The differential speed shall be adjustable.

The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.

For safe operation, contractor shall provide control panel showing proper Sequence of operation with interlocking.

Chutes and interconnecting piping shall be provided with flexible joint (minimum 10 mm flexible in all direction) to avoid vibration.

Instrument Air Compressor with Air Receiver and Dryer

(If required)

Rotary screw Air Compressor with Air receiver and dryer of suitable capacity shall be provided for instrument air supply.

The compressors shall be designed and constructed for a minimum service life of 20 years. The equipment shall be designed for continuous operation for a minimum period of 16000 working hrs at specified duty conditions. The minimum outage shall be limited to replacement of cylinder packing and valves as dictated by the maintenance schedule.

The compressors and the drivers shall be designed to run satisfactorily up to trip speed and relief valve setting without damage.

Compressor shall be supplied with V-belt drive and guard, suction air filter, silencer, automatic unloaded and control equipment, safety / pressure relief valves, common bed plate for compressor and motor, high temperature protection by fusible plug in the compressor outlet, low lube oil pressure switch, isolating valve and all necessary accessories required to form a fully-automatic unit supplying compressed air, continuously or intermittently as required, and at the specified rate and pressure. The pipe work and valves shall be arranged so that either of the compressors can be used to supply the compressed air to the surge vessels.

Compressors shall be rated for continuous operation at full duty.

The motor shall be suitable for star delta starting with 415 V, 3 Phase, and 50 Hz supply. The power supply to control panel for auto / manual system together with power and control cabling between the panel and compressor and cabling to all accessories such as level switches, pressure / temperature devices and solenoid valves shall be provided.

Compressor systems for the supply of air for the operation of valves and instruments shall comprise compressors, after-coolers and air/dryers, duty/standby air receivers together with control equipment, oil eliminating filters, flow regulators and oil mist lubricators as required.

Air Filter

Bidder shall provide a dry disposable type air intake filter sized for 150% capacity (Suitable for removing 1 micron or higher size particles with a minimum efficiency of 99.5%) cum silencer. The air intake shall be at least 5 mtrs above the ground level with provision of support and access for maintenance. An inertial separator with dust removal facility ahead of the fine filter is recommended.

Bidder shall provide the pressure differential switch with facility for an alarm when the pressure drop becomes excessive.

When required the Bidder shall provide a silencer to be located after the air filter along with access and supports for installation to limit the noise below 85 dB.

Air Dryer

Air dryer shall be for operating continuously and alternating on automatic timer between air drying and reactivation of medium. And it shall be designed rated pressure.

The dryer shall be designed, fabricated and tested to meet the requirement of ASME VIII Div1 for the rated pressure. The inlet and outlet connection on the air dryer shall be of flanged.

Each dryer shall be provided with duty and standby safety relief valves, dryer pressure relief system shall be provided with isolation and interlocking facility to allow only one relief valve on line.

The instrument air quality shall be in accordance with the ISO 8573-1, Class 1. Pressure drops over all the filters at normal working pressure shall be less than 0.1 bar.

1 Duty and 1 standby compressor sets shall be provided complete with the following:

- Common base frame for Compressor & Motor
- Air-cooled unit
- Isolating valves
- Air filter and silencer
- Pressure relief valve or excess pressure safety device
- Pressure reducing valves
- Pressure gauges
- Off-loading piston
- Automatic changeover (failure of duty unit)
- Drain pipes
- Isolating valve
- V-Belt drive arrangement with Belt Guard
- Stoppers
- Air-receivers
- Others necessary appurtenances

Fire Extinguishers

Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is stringent. All the extinguishers shall have ISI mark / TAC approved. Two nos. of capacity of each 2 Kg shall be provided.

Electrically Operated Hoists

Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust-proof push button station, contractor panel, all wiring, limit switches, etc.

Electric hoist of suitable capacity shall be provided for Membrane (MBR) tank, Centrifuge and Equalisation tank.

Electric hoists shall conform to IS:3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section. Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core.

Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in 'OFF' position or in the event of power failure.

Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS:325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

The electric hoists shall be of Class II duty.

25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer's works

Contractor shall provide access of Chain Pulley Block / electric hoist with monorail for the equipment, weighted more 200 kg. And also in case of regular basis operation of 'more the 20 kg equipment', electric hoist with monorail is to be provided. The capacity of hoist shall be of 1.25 times weight of the heaviest item to be lifted.

Hand Operated Hoists and Trolleys

Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S. 1663/B.S. 3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S.2525-32:1954. Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

Sluice Gate

Sluice gate of suitable size approved as per Hydraulics, process flow diagram and layout shall be provided. The construction of sluice gate shall be in accordance with the specification and generally as per AWWA C501 or IS: 13349. The sluice gate shall be capable of performing the duties set out in this specification without undue wear or deterioration. They shall be constructed so that maintenance is kept to a minimum. All parts of sluice gate, including lifting mechanism components shall be designed for the maximum heads specified with a minimum safety factor of five. Sluice gate shall be of the rising spindle type.

a) Frame

The frame shall be of ample section and cast in one piece. All surface forming joints and bearings shall be machined. The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

b) Guide

Guide shall be bolted to the frame or cast integrally with it and shall be machined on all bearing and contact faces. The length of guide shall be such that it should support the gate up to the horizontal line of stem nut pocket. Arrangement shall be made to prevent lateral movement of bolted on guides. They shall be capable of taking the entire thrust produced by water pressure and wedging action. Wedges or wedge facings shall be attached securely to the guides at points where, in the closed position, they will make full contact with the wedging surfaces on the slides.

c) Seating Faces

Seating faces shall be made of full width, solid section, and dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gate. The faces shall be of ample section and finished smooth. The maximum clearance between the seating surfaces, with the slide in the closed position shall not exceed 0.10 mm.

d) Wedging Devices

Sluice gate shall be equipped with adjustable side, top and bottom wedging devices as required to provide contact between the slide and frame facing when the gate is in closed position. All faces shall be machined accurately to give maximum contact and wedging action. Wedges shall be fully adjustable with suitable adjusting screws and lock-nuts and so designed that they will remain in the fixed position after adjustment.

e) Gate Slides

The slide shall be with strengthening ribs where required and a reinforced section to receive the seating faces. The slide shall have tongues on each side extending its full length, and the tongues shall be machined accurately on contact surfaces. Surfaces of the slide that come in contact with the seat facing and wedges shall be machined accurately. The maximum allowable clearances between the slide and the slide guide shall be 1.6 mm. An integrally cast stem nut pocket with reinforced ribs shall be provided above the horizontal center line of the slide. The stem nut pocket shall be provided with drain.

f) Stem Nut and Lift Nut

Gate shall be provided with a lower fixed stem nut for connecting the stem to the slide and a revolving lift nut located in the lifting mechanism in the head stock. They shall be of ample design to endure the thrust developed during gate operation under maximum gate operating condition loads in opening and closing direction. The stem nut and slide shall be constructed to prevent turning of the stem nut in the pocket in the slide. The stem nut shall be threaded and keyed or threaded and pinned to the stem.

g) Stem

The operating stem shall be designed for a tensile strength to withstand force resulting due to closing/opening action. The threads of the stem shall be machine cut or rolled and of the square or acme type. The number of threads per inch shall be such as to work most effectively with the lift mechanism used. The top of the stem shall be provided with a stop collar.

h) Stem Coupling

The coupling shall be threaded and keyed or threaded and bolted and shall be of greater strength than the stem.

i) Stem Guides

Stem guides shall be cast, with bushings and mounted on cast brackets. Guides shall be adjustable in two directions and shall be so constructed that when properly spaced they shall hold the stem in alignment. Number of stem guides shall be such that unsupported length of stem shall not exceed one hundred times its diameter. The guide shall be suitably lined. The slenderness ratio of stem (l/r) shall not be greater than 200.

j) Fasteners

All anchor bolts, assembly bolts, screws, nuts, etc shall be of ample section to safely withstand the forces created by operation of the gate.

k) Wall Thimbles

Wall thimbles are separate pieces required to be embedded in the mass concrete wall before installation of gate. It shall be supplied along with the gate by the gate manufacturer. The wall thimbles shall provide a rigid mounting, designed to prevent warping of the gate frame during installation. The cross section of the thimble shall have the shape of the letter 'F'. The front, or mounting flange, shall be machined and shall be drilled and tapped to the same template used for its particular gate frame. The frame shall be attached to the thimble with bolts or studs. The depth of the wall thimbles is usually equal to thickness of wall but shall not be more than 300 mm. To permit entrapped air to escape as the thimble is being encased in concrete, holes not lesser than 35 mm dia. at not more than 600 mm span, shall be cast or drilled in each entrapment zone formed by the reinforcing ribs or the flange and water stop.

l) Lifting lug

Lifting lugs shall be provided for all gates.

Materials of Construction of Sluice Gate

(a)	Wall thimble	:	Cast Iron IS:210 Grade FG 200
(b)	Frame and Slide	:	Cast Iron IS:210 Grade FG 200
(c)	Seating faces	:	SS ASTM A276 type 316
(d)	Wedge	:	SS ASTM A743 CF8M or SS 316
(e)	Stem and	:	SS ASTM A276 type 316

stem extension

- (f) Stem guide : Cast Iron IS:210 Gr. FG 200
- (g) Stem nut : SS ASTM 743 Gr. CF8M
- (h) Stem coupling : SS ASTM A276 type 316
- (i) Fasteners, anchor : SS ASTM A276 type 316

bolts and nuts

- (k) Lift nut : Bronze ASTM B148
(CA952, CA954 or CA958)
- (l) Flush bottom seal: EPDM Rubber

Valves

Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges. Flanges shall conform to ISO 7005, IS 6392, BS EN 1092-1/ BS 4504.

Valves shall be double flanged type and the faces shall be parallel to each other. The flange face should be at right angles to the valve centre line. Back side of valve flanges shall be machined, or spot faced for proper seating of the head and nut.

Valves buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys. Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.

Valve of diameter 450 mm and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.

Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.

The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.

Valves shall be free from sharp projections which are likely to catch and hold stringy material.

All valves shall be of Minimum PN-10 rating.

Sluice Valves

Sluice valve shall generally conform to IS 14846.

Sluice valves shall be of non-rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage. Shoe and channel arrangement shall be limited to valves of 400 mm and above. The gap between the shoe and channel shall be limited to 1.5 mm.

Valves of 400mm and above shall be provided with thrust bearing arrangement for ease of operation.

Valves of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.

All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.

The material of construction of valve shall be as follows:

S. No.	Component	Material
1	Body and Doors	Cast Iron : IS:210 Gr FG 220
2	Spindle	Stainless Steel: BS:970 Gr 431
3	Seat Rings	Stainless Steel: BS:970 Gr 304
4	Back seat bush	Bronze : IS:318 Gr LTB2
5	Shoe and channel linings	Stainless Steel : BS:970 Gr 304
6	Internal Fasteners	SS 316

Knife Gate Valves

The valve shall meet requirements of MSS SP 81.

Outer body shall be provided with inner liner in corrosion resistant Stainless Steel which shall extend into the gland. The body shall be devoid of any wedge / dead pockets to avoid settling of suspended particles and solids in the service fluid.

The gate/plate shall be precision buffed and the edge contoured to a knife edge. The gate shall move along / be guided by the seat ring to ensure that it scrapes any deposit / scale, enabling smooth uninterrupted movement.

Seat shall be so designed that there is no recess / relieved groove to harbor deposition that could build-up and swamp the valve. The design to also incorporate bosses that guide the gate and avoid deflection, ensuring positive shut-off.

The stem shall have double start threads cut in order to ensure smooth and speedy operation.

Gland packing shall offer minimal frictional resistance and precludes external lubrication. As positive sealing element, the packing shall also include a resilient rubber ring.

The knife edge and seat face in flow path shall be hard faced to a hardness of 400 to 450 BHN to counter erosion. In such cases, provision shall also be made to ensure the fluid contact with the seat ring is minimal.

The material of construction of valve shall be as follows :

Sr.No	Component	Material
1	Body	Cast Iron : IS:210 Gr FG 260
2	Inner lining	Stainless Steel: BS:970 Gr 304
3	Knife gate / plate	Stainless Steel: BS:970 Gr 304
4	Stem	Stainless Steel : BS:970 Gr 304
5	Seat ring / Boss	Stainless Steel : BS:970 Gr 304
6	Gland housing	Cast Iron : IS:210 Gr FG 260
7	Gland packing	Teflon impregnated with the asbestos + rubber

Non-Return Valve

The valves shall be suitable for mounting on horizontal/vertical pipe line.

The internal parts shall be easily accessible for inspection through inspection hole.

Hydraulic passages and doors shall be designed to avoid cavitation.

Valves shall be of swing type or ball type. Ball valves must house a freely moving ball in such a way that return flow is effectively prevented.

Valves shall be quick closing type with non-slam characteristics. In case of swing type, the non-slam characteristics shall be achieved by providing suitable combination of door and hydraulic passages without any external lever/damping arrangement.

Valves 450 mm and above shall be provided with supporting foot.

Swing door valves of size 600mm and above shall be of multidoor type.

Direction of the flow shall be clearly embossed on the valve body.

Maximum pressure drop across the valve shall be 0.4 mwc.

Maximum allowable leakage rate shall be 7cc/hr/mm diameter.

The material of construction of valve shall be as follows:

Sl. No	Component	Material
1.	Body and Door	Cast Iron : IS 210 Gr. FG 200
2.	Body and Door Ring	Stainless Steel : ASTM A743 CF8, BS970 Gr. 304 S11
3.	Hinge Pin	Stainless Steel : BS970 431 S29
4.	Bearings	Teflon

Pressure / Vacuum relief valves

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurised in excess of a preset maximum allowable pressure. The valves shall be drops tight under no flow conditions.

Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow conditions.

The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

Body ends shall be flanged and drilled to BS EN 1092-1/BS 4504.

Spares and consumables

The mandatory spares and consumables required for satisfactory, and trouble free operation of the plant shall be included in quoted price and recommended quantity shall be submitted by the bidder.

Pipe work and Fittings

Contractor shall be responsible for coordination and location of all piping and equipment with the Main Contractor and other Contractors before installation. Contractor shall be responsible before commencing work for checking all levels / gradients shown on drawing and for relating them to site conditions and restrictions shown on drawings including architectural, structural, etc., to ascertain that conditions on site permit execution of work as shown on drawings.

All pipes, fittings, joints, and jointing media used shall be suitable for the substances conveyed in the pipes and shall not deteriorate due to chemical or atmospheric action. The pipes and fittings shall have ample strength for the pressure involved.

Contractor is to provide, for dissimilar metal joints in the piping system, special flanged connections with insulating gaskets plus insulating sleeves for the flange bolts.

All pipe work shall be free from burrs, rust and scale and shall be thoroughly cleaned before erection. Open ends during the progress of work shall be blanked-off with purpose-made metal or plastic caps with proper protection and the use of wooden plugs is forbidden. Should any stoppage in the circulation occur after the various systems have been put into operation, owing to non-compliance with this requirement, the Contractor shall rectify the matter at his own expense.

Pipes are to be installed with correct falls for venting and draining and attention must be paid to neatness of installation. Groups of pipes to be accurately spaced and valves, joints, etc. symmetrically arranged. Where two or more pipes are visible and change direction together,

bends shall be struck from a common radius points. Adequate clearances to be maintained at all cases, to allow for the application of the insulation and finishing if any.

Valves etc. should be installed in such a manner that future maintenance of glands, etc. is made as easy as possible. All hand wheels must also be accessible.

On all systems long radius bends and pitcher tees are to be used wherever possible. All fittings to be suitable for a working and test pressure not lower than that specified for the pipe work system concerned.

Reductions in bore of pipe to be made eccentric for horizontal pipes (to prevent air locking) and concentric taper fittings are to be fitted for vertical pipes.

Access shall be provided at the base of all stacks, opposite joints, on bends and elsewhere where required whether shown on the drawings or not and in such a position that they can be conveniently inspected and cleaned at all times.

Positioning of Pipe work:

The position of pipe work shown is approximate and the Contractor is required to produce detail drawings showing pipe runs, and levels and conflicts / crossovers with other services, and to submit these to the Architects / Consultants for approval.

All pipes runs when not underground or in ducts shall be concealed as far as possible by careful positioning or shall be chased into walls, laid in screed, etc. as directed by the Consultant.

All vertical and horizontal runs of pipe work, unless adjacent to concrete ceilings to be built into walls in the lavatories and elsewhere.

All exposed pipe work to be parallel to the building grid, diagonal pipe runs will not be accepted.

Where required the Contractor is to mark, free of charge, the exact position of the pipes on site before installation commences.

Pipe runs, where exposed, shall be positioned at least 40mm from the finished surface or hard against the finished surface as directed by the Consultant.

Pipe Supports:

All pipe supports shall be mild steel with epoxy coating.

The use of flat bar as supports shall be strictly limited to a length of 80mm only. Weld fabricated supports, comprising or pad with two fixing bolts to structure, steel angle post, terminating with split pipe rings, shall be used. Steel tubing may be used in lieu of angle, but steel rods shall not be permitted.

All pipe work, fittings, valves, connections, etc. shall be sufficiently supported and bracketed. All pipe work shall be supported at intervals, not greater than the following on straight runs; and additional supports shall be provided at bends, valves, etc.

All pipe supports shall be of such design and type to allow for the removal of any pipe section without the necessity of disconnecting other adjacent pipes.

Wherever possible exposed Pipe work shall be supported against the finish wall or soffit with 'Saddle' brackets.

The discharge pipe work from pumps and all pipe work where vibration could be transmitted to the building structure shall be supported with brackets etc. through neoprene-in-shear hangers or with tough neoprene / rubber washers at contact of bracket to pipe.

Contractor shall be responsible for the building in of all supports, etc. and when tendering, shall allow for bolt fixing for concrete, and brilling and building in brackets in brick work, etc. All fixing details / method should be well coordinated with the Main Contractor / other Contractor. Contractor shall particularly note that if it is not possible to fix the supports directly above the pipes to be supported, then cantilever supports shall be used.

Sleeves:

Where pipes pass through walls, floors, ceilings, etc. the Contractor shall provide pipe sleeves. Sleeves shall be black steel; and be of short pipe length. Where sleeves are fitted through floors they shall extend to at least 100 mm clear of the finished floor. Where sleeves are fitted through external walls which are not fire barrier walls, the sleeves shall be GI.

Sleeves shall be of sufficient size to allow free movement of pipes and furthermore, where pipes are insulated the sleeves are to be oversized to allow the insulation to be carried through the sleeves.

The gap between a pipe and its sleeve shall be packed with fiberglass blanket material. However, for pipes / sleeves through fire barriers, the gaps must be firmly sealed with soft packing having a period of fire resistance equal to the fire barriers. The ends of sleeves are to be caulked with non-hardening mastic to the Consultant's approval.

Details of pipes through walls and floors shall be approved by the Government Authority and the Consultant before installation.

Contractor shall set all sleeves in walls, floors, etc. and in shuttering before concrete is poured. Contractor shall also be responsible to check all the sleeves are put in the correct locations and levels and are in correct sizes for their installation of pipe work.

Velocity:

All pump suction shall be designed for velocity not more than 1.5 m/s, the pump discharge shall be designed for velocity not more than 2.0 m/s, all gravity pipelines shall be designed for velocity 0.8 m/s, and all air lines shall be designed for velocity not more than 15 m/s.

**11.0 TECHNICAL SPECIFICATIONS FOR INSTRUMENTATION & CONTROL FOR SEWAGE
TREATMENT PLANT, CTBD EFFLUENT TREATMENT PLANT AND REVERSE
OSMOSIS SYSTEM**

12.1	SPECIFIC INSTRUMENTATION AND CONTROL REQUIREMENTS
	Bidder to provide I&C equipment & systems for entire Sewage Treatment Package as specified.
12.1.1	SCOPE OF WORKS FOR I&C SYSTEM
	Supply, erection, and commissioning of all field instruments (gauges/ sensors/ transmitters/ switches etc.) for control/ monitoring/ alarm annunciation for complete Sewage Treatment Plant, CTBD Effluent Treatment plant and Reverse Osmosis system equipment & systems on as required basis together with specified requirement detailed subsequently.
	Supply, erection & commissioning of PLC based control system for complete sewage treatment plant comprising of sewage water intake & screening, grit removal, equalisation tank, anoxic tank, aeration tank, MBR system, chemical dosing system, Filtration system, UF system, RO System, treated water tank & transfer pumps system equipment complete with all hardware, software, system cabinets, marshalling cabinets, interfaces & accessories as required with specified requirement detailed subsequently. The system / panel should be compatible for software integration with any third-party services over any open protocol.
	Supply, erection & commissioning of all erection hardware and accessories for cable trays, junction boxes, power distribution board including structural steel support.
	Supply, erection & commissioning of Local 230 V AC UPS Power supply distribution boards & distribution to Bidder's I&C system equipment.
	Supply, laying & termination of Instrumentation, power supply & Control cables as required for complete control/ monitoring of entire sewage treatment plant.
	Supply of necessary consoles & other furniture & accessories to mount MMI & peripherals including two (2) Nos. good quality high back cushioned wheeled chairs each in STP, CTBD Effluent Treatment plant and Reverse Osmosis system LCR envisaged at Electrical and I&C common building.

	Supply of Commissioning and Essential spares as following:	
	a)	Commissioning Spares: On as required basis.
	b)	Essential Spares: As specified subsequently.
	Submission of engineering documentation as specified.	
	Provision of any other Instrumentation and control equipment not specified but required for proper functioning of the system.	
12.2	SPECIFIC I&C SYSTEM EQUIPMENT REQUIREMENT (INCLUDED UNDER BIDDER'S SCOPE)	
	PLC Based Control System a) Controllers as required complete with required I/O modules to be located at plant local control room (air conditioned). Size of PLC controller to be based on I/O handling capacity, specified I/O spare philosophy and controller spare loading requirement. b) PC based VDU/Keyboard type Operator Cum Engineering Stations (OES) complete with SCADA MMI software to be located in plant local control room (LCR) complete with associated furniture for mounting the same. c) One (1) No. A4 size B/W laser printer. d) Provision of communication hardware for redundant OPC communication link (Ethernet on TCP/IP protocol) for future interfacing with overall site/ plant master control system. e) The system / panel should be compatible for software integration with any third-party services over any open protocol. f) I/O Quantity: I/O channel as required considering the I/O spares philosophy specified below. g) Earthing connection within the panels, cabinets and between bidder's panels, cabinets for both frame and electronic earth to independent Instruments earthing pit are included in Bidder's scope (Refer Electrical	

	systems section for more details). The Bidder shall furnish the requirement of different earthing requirement for Power and PLC. h) Field instruments shall be provided as indicated in the P&ID's. However the instruments indicated are the minimum required any other instruments required for automation and operation of the STP shall be included in the scope of the bidder.	
12.2.1	OPERATION PHILOSOPHY	
	Complete operation & monitoring of complete sewage treatment plant will be carried out from respective local control room (air conditioned) through VDU/KB based Operator Station (OS) to perform normal start-up, shutdown, and emergency operations. In case of failure of PLC system, facility shall be provided to operate the plant manually with required hardwired interlocks for safety of plant. The system functionality should be supervised from control room & control in case of any emergency or failure of system operator work station.	
	When operated from Operator Station operator shall be able to call for various types of displays for all parameters as required on the screen and to perform normal start-up, shutdown and emergency operations of the system/ equipment.	
	In addition to the control room (LCR) operation/ monitoring facility, local start/ stop operation facility from local pushbuttons (LPB) shall be provided for all Motor drives as a testing and maintenance facility as detailed below:	
	a)	Local Start operation (without local monitoring facility) through local push button is envisaged for all uni-directional motor drives. Start command will be interfaced to respective control system. Emergency stop push button will be directly wired to Swgr./ MCC for emergency stop and the operation of the same will be monitored in control system through Operator Station.
	b)	Local open/ close operation (without local monitoring facility) through local push buttons is envisaged for all bi-directional motor drives except for Solenoid operated drives. Open/ close command will be interfaced to respective control system.

	c)	Local/ remote operation location selection will be carried out from LCR located OWS.
12.2.2	CONTROL PHILOSOPHY	
	Complete control and monitoring of complete sewage treatment plant with associated auxiliaries and electrical system shall be carried out in PLC based control system.	
12.2.3	CONTROL SYSTEM DESIGN PHILOSOPHY	
	General Requirement	
	The safety interlock system for the complete sewage treatment plant shall include complete protection for operating personnel and equipment under conditions that may jeopardise their safety without causing unnecessary trips or imposing undue delay during start-up from a standstill condition or following a trip.	
	The design of the safety interlocking system is based on the following basic principles and is intended to shut down the plant and/ or disconnect the plant equipment from the electric power supply under certain abnormal operating conditions.	
	a)	To trip the minimum equipment in the sequence during abnormal operating conditions leaving all the other equipment running which may safely be permitted to continue operation.
	b)	To indicate initiating cause for tripped equipment.
	c)	To prevent restarting of equipment until safe conditions are restored.
	d)	To retain as much flexibility of operation as is consistent with safety.
	e)	To operate from rugged, reliable initiating elements independent of normal control or alarm devices.
	f)	To prevent mal operation of equipment on interruptions and restoration of control voltage.

	g)	To eliminate the necessity for any manual bypassing of an interlock to permit starting and stopping of equipment.
	h)	To emphasise eliminating false trips by providing component reliability.
12.2.4	Specific Requirement for STP, CTBD ETP and Reverse Osmosis system: a. Ultrasonic type level transmitters shall be provided in all tanks used for deriving various tank level conditions for the purpose of alarm/ interlock/ dry run protection of pumps and equipment. b. All the screens shall be auto operated based on level difference in upstream and downstream across the screens. c. The operation of the belt conveyors shall be interlocked with screen operation. d. All flow elements as required for flow measurements will be provided. For measurement of water flow, orifice plates will be used as primary sensing device. Ultrasonic/ electromagnetic type flow meters will be used for large dia. pipe flow measurements. e. All drives of grit removal mechanism shall be auto operated. f. The MBR unit shall be auto operated as per the control logic defined by the technology provider. Operation of the permeate pumps, backpulse pumps, membrane cleaning process, process and membrane aeration blowers shall all be controlled by the PLC. g. Turbidity analyzer shall be provided on the permeate line. Residual Chlorine analyzer shall be provided on the discharge of treated sewage pumps.	
12.3	SPECIFIC I&C SYSTEM DESIGN REQUIREMENT	
	Sensors shall be provided for pre-trip alarm for all protection conditions.	
	Instrument range selection criteria to be followed:	

	a)	For pressure and draft measurements, the maximum operating pressure will be within 70 to 80% of the maximum scale range. All pump suction measurement and steam pressure measurements in extraction steam and in heaters will cover the negative pressure range also and all draft gauges will cover the negative pressure as well as the positive pressure as the case may be.
	b)	For pressure switches and temperature switches, the set points shall fall within 40% to 70% of the scale range selected.
	c)	For level measurement, the maximum of the range shall cover the overflow point or six inches below the top of the vessel and the minimum of the range shall be six inches above the bottom of the vessel. Also, the gauge glasses shall be stacked with overlap to cover permissive, alarm and trip levels.
	d)	For flow measurement, the maximum range shall be fixed at about 10 to 15% above the maximum operating flow.
	e)	For temperature measurement, the maximum operating temperature will be within 80 to 90% of the maximum scale range.
	f)	Size of Tapping point stub and root valve for Pressure and differential pressure measurement shall be 15 NB and for level & flow measurement shall be 25 NB.
	Signal exchange for motor drives between PLC & MCC are detailed in TABLE-1. Control system design for the STP system shall meet the specified requirement.	
	I&C cables usage shall be as follows:	
	For analog & other low level signals (4-20 mA, DC), mV etc. with circuit voltage upto 48 V DC, individual pair shielded & overall shielded instrumentation cables to be used.	
	For binary signals with circuit voltage upto 48 V DC only overall shielded instrumentation cables to be used.	

	For RTD signals, individual pair shielded & overall shielded TRIAD cables to be used.	
	For circuit voltage above 48 V DC/ power supply applications etc. control cables to be used.	
	In all I&C cables, spare cores/ pair to be provided as follows:	
	For multicore / multipair cables, minimum 20% cores/pairs to be provided.	
	230V AC UPS power supply to be used for I&C system equipment including solenoid valves. Any other voltage required for Bidder's equipment is to be derived from 230 V AC UPS power supply. Distribution of complete power supply for Bidder's equipment is included in Bidder's scope of work.	
	Name tag shall be provided for all instruments, control equipment etc.,	
	All panels, cabinets local panels, JB's etc. shall comply with protection class indicated below:	
	a)	Indoor air-conditioned area – IP 32
	b)	Outdoor – IP 65
	For solenoid valves or other pneumatic devices instrument lines separate & independent air filter regulator (AFR) to be provided.	
	Tagging procedure to be followed for complete package.	
12.4	SPECIFICATION OF I&C SYSTEM EQUIPMENT	
12.4.1	Field Instruments	
	All the necessary field instruments like RTD, T/C, Ultrasonic/ Radar Level Indicators, Pressure Switch etc., and Instruments required for other associated systems shall be included in Bidder's scope. All the sub-vendors, make, model, Technical features, QAP tests are subject to Purchaser's approval.	

12.4.2	Pressure Indicators
	Direct reading, pipe mounted Pressure gauges of Stainless Steel with 6 inch phenolic dial (white dial with black numerals), 316 SS Bourdon tube, nylon movements and micrometers type adjustable aluminium pointer with accuracy of $\pm 0.01\%$ of span including accessories like siphons for steam services, snubbers for pump discharge applications and chemical diaphragm for corrosive and oil/suspended solids services and name plate, etc. Material of accessories shall be SS. IP65 degree of protection for enclosure. Over range protection shall be 50% above maximum pressure. Armoured capillary of 15 M shall be provided as required.
12.4.3	Pressure Switches
	Non indicating type, field mounted Pressure Switches of aluminium casing (epoxy coated), and 316 SS element and accuracy of $\pm 0.01\%$ of span, including accessories like snubbers for pump discharge applications and chemical diaphragm for corrosive and oil services, name plate & mounting brackets. Material of accessories shall be SS. Auto reset micro switch with internal adjustment for set values with 2 SPDT contacts rated for 0.2 A at 220 V DC. IP 65 degree of protection for enclosure. Over range protection 50% above maximum pressure. Scale for setting shall be provided.
12.4.4	Pressure Transmitters
	Accuracy: $\pm 0.065\%$ of FSD or better; Over-range protection: 50% of max. pressure; External zero & span adjustment; Rack mounting, LCD display; Power supply: 24 V DC (loop powered); Output signal: 4-20 mA DC, 2 wire with HART protocol; IP 65 protection; Housing material die cast aluminium with epoxy coating; Sensing element/ body/ seal material: SS 316, All transmitters provided will be diaphragm sealed with SS.
12.4.5	Level Gauges
	Tubular/ float type level gauges with brass guard rods & brass holders shall be provided. Material of float & float chord shall be 316 SS & cage material shall be fabricated steel and the material of accessories (name plate, etc.) shall be SS. IP65

	degree of protection for enclosure. Connection shall be screwed or flanged (ANSI class 150 RF).
12.4.6	Level Switches
	Top/side mounted float type level switches shall be supplied with still tubes as required to suit the requirement. Micro switch with 2 SPDT contacts rated for 0.2 A, 220 V DC. Material of float & float chord shall be 316 SS & cage material shall be fabricated steel and the material of accessories shall be SS. IP65 degree of protection for enclosure. Top mounted ultrasonic type (time of flight) level switches for sewage sumps/ equalisation tanks shall be supplied with accuracy of ± 0.25 of span, Housing MOC: PBT, Sensor MOC: PVDF. Accessories like name plate, drain valve for external case type level switches, mating flange, gaskets (asbestos), fasteners, bolts & nuts, etc. shall be supplied.
12.4.7	Level Transmitters
	Capacitance type level transmitters with LCD indicator shall be provided. IP-65 protection, 4-20 mA DC output (2 wire system), +24 V DC supply, isolated and ungrounded electrical circuits, Auto tuning, connector cable of required length, the material of accessories will be SS. All transmitters provided will be diaphragm sealed with SS.
12.4.8	Ultrasonic Flowmeter
	Ultrasonic type level transmitters with transit time principle, single traverse, clamp on type. Accuracy $\pm 1\%$ of reading, Repeatability $\pm 0.3\%$ of reading, LCD indicator shall be provided. IP-65 protection, 4-20 mA DC output (2 wire system), +24 V DC supply, isolated and ungrounded electrical circuits, Auto tuning, connector cable of required length, the material of accessories will be SS. All transmitters provided will be diaphragm sealed with SS.
12.4.9	Magnetic Flowmeter
	Online, flange type. Accuracy $\pm 0.75\%$ of reading. Repeatability $\pm 0.5\%$ of reading. Integral display of flow & totaliser in engg. units. Electronic housing – Di cast aluminium with epoxy coating. Body material – Di Cast aluminium; electrode material – 316L/ ALLOY C-22; Measuring tube material – SS; Liner – hard rubber/

	PTFE. Enclosure protection IP65. All transmitters provided will be diaphragm sealed with SS.
12.4.10	DO Sensor
	Electro chemical type, microprocessor based, Accuracy +/-1% of reading, sensitivity of 0.5 ppb, Continuous measurement, Auto temp. compensation, auto zero & span calibration, self-diagnosis feature, integral LCD display, housing enclosure IP 65, output isolated 4-20 mA DC, Electrode material: Gold cathode & Silver anode
12.4.11	Turbidity Analyser
	Turbidity analyser shall be single channel based on the principle nephelometric (IR A or equivalent. It shall be provided with complete probe, necessary Sample Handling System, transmitter, calibration arrangement and sample disposal arrangement. Transmitter shall be microprocessor based with 4-20 mA output. The complete analyser shall be mounted on the free standing cabinet. The enclosure shall be provided with Air Conditioner. Analyser shall be provided with serial output and shall be integrated with purchaser control system.
12.4.12	pH TRANSMITTER
	The sensor should be able to provide online pH value of aqueous solutions. The system shall provide 4-20mA output. It shall also have optional relay output. a) Power Supply : 18- 24 VDC b) Output signal : 4 mA to 20 mA c) Output Range : 0-12 PH d) Operating Temperature Range : 30 to 140 deg F or 0 to 60 deg C e) Operating Humidity Range : 99% non-condensing f) Enclosure : IP 65
12.4.13	WATER HARDNESS ANALYSERS

	g) The sensor shall continuously monitor hardness of water system. It shall be simple and ready to use. The enclosure shall be IP 62 rating. It shall design for continuous and unattended use. h) i) Range : Upto 100ppm (expressed as mg/l CaCo3) j) Accuracy : $\pm 25\%$ of set point value k) Operating Temperature : 32 to 104 deg F or 5 to 40 deg C l) Operating Humidity : 5% to 95 % non-condensing m) Flow Rate : 50 to 500 ml/min n) Enclosure : IP 62 o) Inlet Pressure : 1 to 5 psig p) Repeatability : ± 4 of set point value
12.4.14	TDS Analyser
	q) Meter shall monitor the TDS (Total Dissolved Solids) levels for drinking water, water filters, hydroponics, Aquariums, Food and Coffee, Pools and Spas and residential RO applications. Measurement range is 0-9990 ppm. r) Automatic Temperature Compensation (ATC) s) 1000+ Hours of Continuous Use TDS Range : 0-9990 ppm (parts per million) Temp Range : 0-80 degrees Celsius Resolution : 1 ppm, 1 degree Celsius Accuracy : $\pm 2\%$ Battery life : 1000 hours

12.4.15	Junction Boxes (JB)
	Wall/ column mounted junction boxes having 32 (2x16) terminals and cable entry only at the bottom and sealed with fire proof compound with quantity as required shall be provided.
12.4.16	System/ Marshalling Cabinets
	These cabinets shall house signal-conditioning cards, input/ output cards, processor cards & associated power supply units. Indoor located, free standing vertical type system cabinets with IP-42 enclosure and with 3 mm thick sheet metal of cold rolled steel; double doors with neoprene gaskets; anti-vibration pads of 15 mm thick; blower & louvers in each cabinet with brass mesh; fire proof compound (50 mm thickness) for sealing cable entry (bottom); fire detector for each cabinet. Beacon lamp shall be provided in each cabinet to indicate the cabinet having fault condition. The colour of the cabinets shall be indicated at detailed engineering stage. Doors shall have concealed type of hinges and swing of 100°. The doors shall be provided both at the front and rear. Power supply distribution shall be provided on per cabinet basis with all associated MCBs, protections, etc. The system cabinets, racks in system cabinets, slots in the racks & the terminals shall have identification numbers. A stainless steel metal tag (plate) shall be fixed to the inside of the door & the layout of the racks, slots & details of the card type/ service shall be inscribed on this metal tag. Each cabinet shall be provided with one each 3 pin receptacles for 220 V AC, 1ϕ, 50 HZ and for +24V DC. Cabinet shall be delivered totally wired. All electronics shall be mounted & wiring connections at these hardwares shall be terminated by Bidder. Quantity shall be as required. All cabinets shall have common key for the locks. In each cabinet a 24 V DC Voltmeter shall be provided to check the Field Interrogation voltage.
12.4.17	Instrumentation & Control Cables
	Instrumentation cables shall be 1100 V AC grade, stranded high conductivity annealed, tinned copper, twisted pair (with min. 10 twists for meter) extruded PVC insulated with overall and/ or individual screening, extruded PVC inner sheathed, galvanized steel wire armoured, extruded outer sheathed with FRLS PVC compound. The conductor size shall be min. 0.5 sq. mm. Triplex cables similar to instrumentation cables can be used for RTDs. Instrumentation cables carrying digital signals shall have overall screening along with drain wire and analogue

	signal carrying cables shall have each pair screening and overall screening along with each pair drain wire and overall drain wire.
12.4.18	Control Cables
	Control cables shall be 1100 V AC grade, multicore, minimum 1.5 sq. mm. cross section, stranded copper conductor having 7 strands, PVC insulated inner FRLS PVC sheathed of type ST-1, galvanized steel wire armoured, and outer sheath made of FRLS PVC compound of type ST-1. In situation where accuracy of measurement or voltage drop in control circuit, warrant, high cross sections as required shall be used. For all CT & PT cables, minimum 2.5 sq. mm. Cables shall be used. Solenoid valve Power supply cables shall be minimum 2.5 sq. mm.
12.4.19	Interposing Relay (IPR)
	Electromagnetic type IPRs with plug-in type connections, suitable for channel/ rail mounting in cabinets; coil rating 24V DC. 2 set of change over contacts rated for 0.2A 220V DC. Freewheeling diode across relay coil and self-reset type status indicator flag (electronic) shall be provided. Interposing relays shall be provided for all the DO's including spares.
12.4.20	Solenoid valves
	Direct operated solenoid valves with shut of class (leakage) IV, body rating ANSI 150 material of SS 304 plunger material of 316 SS, rated for continuous duty. IP 65 equivalent protection class for enclosure. Operating Voltage solenoid valves shall be 230 V AC. Insulation class of "F" for the solenoid, moulded type of coil, single/ dual coil.
12.5	Programmable Logic Controller (PLC)
	Microprocessor based programmable logic controller shall be of reputed make and the equipment supplied shall be of their latest series with proven performance record.
	The Equipment to be supplied shall comprise PLC complete with processor, I/O cards, memory modules, racks, mounting accessories completely wired and tested. The other modules, in the scope of supply shall include power supply modules, PC based Programmer, printer, operating file, system cabinets and signal distribution hardware.

	AI/ AO cards shall be of 16 channel type (maximum) and DI/ DO cards 32 Channel type (maximum).	
	All digital inputs shall be potential free and the interrogation voltage from PLC shall be 24 V DC. The digital outputs from PLC shall be 24V DC logic level signal which drives the interposing relays (IPR). IPRs for motorised drives will be located in MCC.	
	PLC system shall meet the following	
	a)	Power supply variation with limits: Voltage variation + 10%; Frequency variation + 5%; Voltage & frequency combined variation + 10%
	b)	All card replacements on power on conditions etc.
	The PLCs processors and PC based operator terminal shall be mounted in standard cabinets/ consoles and these cabinets shall be located in the ACV System control room.	
	The OES shall have a 21" LED TFT Monitor with latest processor, 3 GHz, 2 GB RAM, 1 TB SCSI HDD, DVD R/RW and Multimedia Speakers.	
	The PLC offered to be compatible to standard OPC communication with Ethernet on TCP/IP protocol for establishment of redundant link with the future envisaged master control system for entire plant.	
	DVDs shall be provided for data handling facility for control system software features of control and engineering. Provision shall be made for accessing DVDs and this shall enable easy file handling/ data transfer.	
	PLC system located in air-conditioned area shall also be designed to operate for short periods (minimum 2 hours), when air-conditioning system is not available without loss of any function.	
12.6	TRAINING REQUIREMENT	
	Vendor shall provide training course on offered PLC system in the following areas:	

	a)	Maintenance training
	b)	Hardware training
	c)	Application Software training
	d)	Operation training
12.7	TESTS	
	Bidder shall include Integrated factory acceptance test (FAT) of the system at his works. This shall include inspection by Purchaser or Purchaser's representatives. FAT procedure is subject to Purchaser's approval and the duration of FAT shall be minimum 7 days.	
	On site tests: Bidder shall include testing and commissioning of the PLC at site as Site Acceptance Test (SAT). Inspection of equipment on arrival/ Preliminary on site checks/ tests/ Start-up test/ Trial operation test/ System documentation checks/ Acceptance tests-Similar to the authorisation to ship test but with actual inputs/ outputs.	
	Availability Guarantee test: System availability shall not be less than 99.7% and shall be demonstrated by an analysis of system availability during system design.	
	Tests to be included for individual instruments shall be as per enclosed TABLE-2.	
12.8	SPARES	
	Startup spares shall be as required	
	Essential spares shall be supplied as detailed below:	
	a)	For field instruments, air filter regulators, E/P converter and junction box and drive modules a minimum of one (1) No., or 10% of the quantity of each type and range, whichever is higher, shall be provided.
	b)	PLC System

		i)	All modules like Signal distribution modules, signal conditioning modules, I/O modules, Processor modules, Power supply modules, Network cards etc., – 10% of each type, or minimum one (1) No. whichever is higher.
		ii)	Each type of fuse – 5 Nos., or 30% of each, whichever is higher.
	c)	System Cabinets	
		10% of each type, or minimum one (1) No. whichever is higher shall be supplied for the following	
		i)	Fuses of each type and rating.
		ii)	MCB of each type.
		iii)	Terminals of each type
		iv)	Male & female parts of pre-fabricates Cables – 6 Nos. of each type.
	d)	Solenoid valves (for each valve):	
		i)	Coil – 2 Nos. of each rating and insulation.
		ii)	Plunger – 1 No. of each type and size.
		iii)	Seat – 1 No. of each type and size
		iv)	Gaskets – 2 sets of each type and size.
		v)	O-rings – 5 sets of each type and size.
		vi)	Diaphragm – 2 Nos. of each type and size.
	e)	Wiring, Termination & Accessories.	
		10% of each type, or minimum one (1) No. whichever is higher shall be supplied for the following	

		i)	Fuses of each type & rating.
		ii)	Miniature circuit breaker of each type & rating
		iii)	Terminals of each type.
		iv)	Space heater with thermostatic controls.
		v)	Fire detectors.
		vi)	Blower.
		vii)	Blank CDs for software back-up: 30 Nos.
		viii)	Cable clamps each type.
		ix)	Male & female prefabricated cables – 6 Nos., each type.
		x)	Spare terminal in each terminal block in all cabinets.
		xi)	Spare space for counting additional terminal blocks in all cabinets.
		xii)	Wiring raceways to accommodate additional 30% space of total quantity.
12.9	DOCUMENTS TO BE SUBMITTED ALONG WITH BID		
	a)	System PIDs	
	b)	System write up	
	c)	Control/ Operation/ Design Philosophy	
	d)	PLC system configuration With Technical Literature & PLC Requirements	
	e)	PLC Sizing Details	
	f)	List of Spares	
	g)	Quantity of PLC Cabinets With tentative dimensions	

	h)	Power consumption details for I&C equipment-List of Feeders with Feeder Loads
	i)	Confirmation of all the clauses of the specification/ deviations
12.10	DOCUMENTS TO BE SUBMITTED BY VENDOR AFTER AWARD OF CONTRACT	
	Following documents shall be furnished by vendor	
	a)	System PIDs
	b)	System write up
	c)	Control Schemes/ Control logics with write-up
	d)	PLC I/O List
	e)	G.A Drawing For PLC cabinets
	f)	List of Feeders with Feeder Loads for 230 V AC (UPS)
	g)	Time stamping protocol required for PLC system from GPS master clock supplied by Purchaser
	h)	Data sheet along with catalogues of manufacturers for all field instruments and equipment supplied by vendor.
	i)	Junction Box Grouping Details
	j)	Cable Schedule
	k)	Interconnection Schedule
	l)	Data sheet along with catalogues of manufacturers for all field instruments and equipment supplied by vendor
	m)	QA Plan For I&C Equipment
	n)	Final List Of Essential Spares
	o)	Earthing requirement for PLC system cabinets.
	Vendor to furnish engineering documents in the format as detailed in TABLE-3.	

Table – 1

Signal Exchanges Between PLC & MCC For Drive Control

Sl. No.	From	To	Signal Description	Remarks	PLC Signal Type
A	FOR LT UNI-DIRECTIONAL MOTOR DRIVES				
1	PLC	MCC	Command To Start	CMD to MCC	DO
2	PLC	MCC	Command To Stop	CMD to MCC	DO
3	MCC	PLC	Motor Running	Feedback to PLC	DI
4	MCC	PLC	Motor Tripped (Thermal Overload)	Feedback to PLC	DI
5	MCC	PLC	Motor Ready To Start (By adding Thermal O/L not Operated/ Control Supply available/ MCC not isolated)	Feedback to PLC	DI
6	MCC	PLC	Motor Current (4-20 mA DC)	Feedback to PLC (For Motor KW> 30)	AI
7	LPB	PLC	Local Start Command	CMD to PLC	DI
8	LPB	MCC	Emergency Stop Command	Wired to MCC	-
9	LPB	PLC	LPB Emergency Stop Command Operated	LPB Stop Operated Feedback to PLC	DI
10	N/E SWGR.	PLC	N/E Bus Undervoltage	Feedback to PLC (Common for all applicable N/E	DI

Sl. No.	From	To	Signal Description	Remarks	PLC Signal Type
				Swgr. Service drives)	

NOTES (FOR TABLE-1):

- 1 All 'DI' signals to be interfaced to PLC are Potential Free Contact (PFC) type.
- 2 In case of uni-directional & Bi-directional motor drives, all 'DO' commands from PLC to SWGR./ MCC are 24 V DC logic level type. 24 V DC IPR to be located in SWGR./ MCC (vendor's scope of supply).
- 3 In case of SOVs, all 'DO' commands from PLC are potential free contact type taken from 24 V DC IPR (in PLC vendor's scope of supply).

Table – 2**Tests To Be Performed For Field Instruments**

- 1.1 Accuracy, repeatability, Calibration tests, hydro test (1.5 times max. pr), over range test (1.5 times range) shall be provided for all field measuring instruments.
- 1.2 Material test (for all temp. meas.ins), insulation test (for RTD & T/C), Bore concentricity test: $\pm 5\%$ for thermometers, RTDs, T/Cs & $\pm 1.5\%$ for temperature switches.
- 1.3 Functional tests, temperature rise test, HV test, insulation tests, and contact rating test for Inter Posing Relays.
- 1.4 Verification of Degree of protection, type & routine tests as per relevant Indian Stds. for local, system panels.
- 1.5 Compensating cables: Thermo-emf characteristic/ Continuity test/ Measurement on capacitance, inductance, and loop resistance/ Insulation resistance/ High voltage test as per latest IS/ Tensile and elongation test/ Oxygen index test/ Any other test applicable.

Table – 3

Engineering Documents Format

Bidder shall prepare the engineering documents in this table & submit for Employer/ Engineer's review & approval. The engineering documents shall have all fields as listed under 'Details of Fields' in this table and the Bidder shall furnish all the engineering documents in CD or DVD in addition to hard printout for each revision. Finally Bidder shall submit as installed and commissioned drawings/ documents.

SL	TYPE OF DOCUMENTS	DETAILS OF FIELDS		
1.	Drive List	1,	Sl. No. (*), tag number.	
		2.	General Data	
			(a)	Bidder: Motor (Bidder's name) (*), drive equipment (*).
			(b)	Type/ Form: Type (*), reference standard (*), manufacturer's dwg. No.
			(c)	Mounting, coupling method (*).
			(d)	Motor Equipment Location: Layout dwg. No. co-ordinates, elevation.
		3.	Data required for electrical engineering:	
			(a)	Rating: Output (kW) (*), full load speed (RPM) (*), voltage.
			(b)	Enclosure, Indoor/ Outdoor, starting method, direction of rotation, winding insulation class, Integral starter, Integral starter wiring diagram No.

			(c)	Space Heater: Number provided, Rating (kW)
			(d)	Performance at rated volts & Hz: Rated current (IFL) Amps (*) starting % IFL (*), starting current %IFL (*), power factor (*), starting torque %IFL, pull out torque.
			(e)	Terminal box: Cable size (mm ²), cable OD (mm), location.
		4.	Data required for instrumentation & control	
			Type of control (interlocked/ non-interlocked), Type of operation, Type of actuator, Control cable gland size, status/ position feedback, actuator wiring diagram No., local control panel operation, control system scope.	
		5.	Solenoid Valve Data (*)	
			(a)	Sl. No. Service, fluid (*), quantity (*)
			(b)	Type: 2 way, 3 way, 4 way.
			(c)	Size: Pipe, Body, Orifice
			(d)	Operating conditions: Pressure – (kg/cm ²)
			(e)	CV: Selected, Rated
			(f)	Action: Coil # 1, (E/DE), Coil # 2 (E/DE)
			(g)	Coil: Single coil
			(h)	Voltage 110V AC, 220V DC.
			(i)	VA: Normal, Inrush.

2.	Inputs to Bidder from Purchaser's System	Sl. No. signal category (analog/ digital), signal type (isolated 4-20 mA DC/ NO/ NC/ CO), No. of signals required by Bidder, Vendor tag No., signal description, signal range/ set value, signal destination in Bidder's system, purpose, reference dwg. No. Remarks.		
3.	Outputs from Bidder's System to Purchaser's System	Sl. No. signal category, signal type, No. of signals available to purchaser, vendor tag No., Signal description, signal range/ set value, signal location in Bidder's system, purpose, Reference dwg. No., contact rating, Remarks.		
4.	Junction Box Schedule	Vendor JB No. service description, instrument/ signal tag. No., terminal No., -/ com, terminal No. SH/ NC, Incoming cable type, Incoming cable No., JB location, Remarks,		
5.	Terminal Details – Analog	Sl. No., signal description, signal category (AI/ AO), source equipment, source equipment tag No., vendor tag No., signal type (RTD/ T/C/ 4-20 mA DC), terminal block No., terminal numbers (+, -, SH), Reference dwg. No.		
6.	Terminal details – Digital	Sl. No. signal description, signal category (DI/ DO), source equipment, No., vendor tag No., contact type (NO/ NC/ CO), terminal block No., terminal numbers (NO, C, NC) Reference dwg. No., Remarks		
7.	Schedule of Instruments with Settings	(a)	Sl. No., (Service Status condition to be indicated for contact signals), Scope, Instrument type, (Indicator/ Switch/ Transmitter, etc.)	
		(b)	General Data	
			Vendor tag, Location in elevation/ rows/ columns, flow diagram reference	
		(c)	Design Data:	
			(i)	Pressure: (Kg/cm ² , unit shall be mm wcl for sub-atmospheric pressure): Normal operating pressure, maximum operating

				pressure, design pressure, design temperature.
			(ii)	Temperature (0C): Type of element (For RTD – PT100, C4-53 & for T/C – K.R.S.J, etc.,) normal operating temperature, maximum operating temperature, and design temperature.
			(iii)	Flow: Fluid, pipe size, velocity (mts/sec), viscosity, maximum pressure loss, normal flow (m3/hr), maximum flow (m3/hr), design flow (m3/hr), DP at maximum flow (mmwcl).
			(iv)	Level: Normal level, maximum level, instrument range, engineering units.
			(v)	Accessories, body rating (ANSI), remarks (redundancy of instruments to be indicated here).
8.	List of panels/ cabinets & control room mounted equipment	Sl. No., control room layout reference, description, tag No., panel/ cabinet, location, qty/ unit, scope, dimensions – height (mm), width (mm), depth (mm), weight (kg), power dissipation (watts), reference dwg. for panel mounting dwg. No. showing external wiring, remarks.		
9.	3rd party instrument list	Sl. No., description, vendor tag No., location, qty./ unit, scope, dimensions-height (mm), width (mm), depth (mm), weight (kg), power dissipation (watts), reference dwg. No., showing mounting details, reference dwg. No. showing		
11.	Equipment List	Equipment, equipment code, equipment location, remarks.		

12.	Cable List (For all cables in Bidder's scope)	Cable scope, cable No., cable type, source, source location, destination, destination location, signal tag No., service description, remarks, cable length in metres.
13.	Loop Drawings	Loop Drawings shall be submitted for all signals between the field instruments & system cabinet/ local panels in Bidder's scope of supply. The loop drawing shall indicate the field instrument tag No., service, field JB No. (to which the instrument is connected), system cabinet No., TFT/ CPU indicator/ to Purchaser's system. The drawing shall also indicate the terminal numbers, polarity & cable numbers for all junctions & hardware/ components forming the loop. Loop drawing shall be prepared for each & every signal going to Bidder's system.

Technical Data Sheets - Sewage Treatment Plant (STP)**(To Be Filled and submitted by the Contractor after Award of Contract)**

Contractor shall furnish all relevant catalogues relevant to the equipment required in the proposed STP, CTBD ETP and RO system.

In case of datasheet for any equipment is not available, vendor can furnish datasheet in their own format.

a. Process and Civil Units

Sr. No.	Units	Employers Requirement	Contractor to Indicate
1.1	General & Process		
	Total land area proposed for STP.	34.5 x 12.5 m	
1.2	Sewage Treatment Plant		
1	Manual Fine & Coarse Screen Chamber		
	i. No. of units	1W	
	ii. Capacity of each unit in MLD	To handle peak flow	
	iii. Dimension of chamber (m)		
2	Oil & Grease trap	1W	
	i. Dimension (m)		
	ii. HRT (hrs)		
3	Equalization Tank	1W	
	i. Dimension (m)		
	ii. HRT (hrs)		
4	Anoxic tanks(s) / Zone(s)		
	i. No. of tanks / zones		

Sr. No.	Units	Employers Requirement	Contractor to Indicate
	ii. Volume of each tank (m3)		
	iii. Dimension (m)		
	iv. HRT (Hrs)		
	v. Depth of Liquid (m)		
	vi. Recirculation ratio		
5	Aeration Tank		
	i. No. of tanks		
	ii. Volume of each tank (m3)		
	iii. Dimension (m)		
	iv. F/M ratio (Kg BOD removal / Kg		
	v. MLSS (mg/l)		
	vi. MLVSS (mg/l)		
	vii. SRT (days)		
	viii. Recirculation ratio		
	ix. Excess Sludge (kg/day)		
	x. Operating DO in Tank (mg/l)		
	xi. HRT (Hrs)		
	xii. Depth of Liquid (m)		
6	MBR Tank		
	i. No. of tanks		
	ii. Volume of each tank (m3)		
	iii. Dimension (m)		
	iv. Membrane effective surface		

Sr. No.	Units	Employers Requirement	Contractor to Indicate
	v. No. of Modules/cassettes		
	vi. Design flux	Max 25 LMH	
	vii. Trans-Membrane Pressure		
7	MBR Permeate Tank		
	i. Dimension (m)		
	ii. HRT (Hrs)		
8	Sludge Holding Tank		
	i. Dimension (m)		
	ii. HRT (Hrs)		
9	CTBD Collection Tank		
	i. Dimension (m)		
	ii. HRT (Hrs)		
10	UF Feed tank		
	i. Dimension (m)		
	ii. HRT (Hrs)		
11	CTBD UF permeate Tank/ RO Feed Tank		
	i. Dimension (m)		
	ii. HRT (Hrs)		
12	RO Permeate tank		
	i. Dimension (m)		
	ii. HRT (Hrs)		
13	RO Reject tank		
	i. Dimension (m)		

Sr. No.	Units	Employers Requirement	Contractor to Indicate
	ii. HRT (Hrs)		
14	Centrifuge area	To accommodate 1W Centrifuge	
	Dimension (m)		
15	UF system area	To accommodate 1W Centrifuge	
	Dimension (m)		
16	RO system area	To accommodate 1W Centrifuge	
	Dimension (m)		
17	MCC Room		
	Dimension (m)		

TECHNICAL DATA SHEETS**PART-B STP- MECHANICAL****(To be filled and submitted by the Contractor after Award of Contract)**

Contractor shall furnish all relevant catalogues relevant to the equipment, required in the proposed STP

A. Manual Bar Screen (Coarse Screen)

Sl. No.	Description	Units	Particulars
	Coarse Bar Screen		
a	Quantity		
b	Screen size		
c	Opening size		
d	MOC		
e	Size of bar		
f	Width		
g	Height		
	Container		
a	Capacity		
b	MOC		
	Fine Bar Screen		
a	Quantity		
b	Screen size		

Sl. No.	Description	Units	Particulars
c	Opening size		
d	MOC		
e	Size of bar		
f	Width		
g	Height		
	Container		
a	Capacity		
b	MOC		

B. OIL & GREASE TANK / SKIMMER

S. No.	Description	Units	Particulars
a	Quantity		
b	Chamber dimensions (L x B x H)	mm	
c	Surface Loading Rate	m ³ /m ² /d	
d	Retention time	Min.	
e	Drive details		
G	Oil Skimmer Details		

S. No.	Description	Units	Particulars
	Container		
a	Capacity		
b	MOC		

C. Submersible Pump Set (Equalised Sewage Transfer Pump to Anoxic Tank)

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		
	Model		
	Type		
	Quantity (W+S)	Nos.	
(b)	Performance		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	

Sl. No.	Description	Units	Particulars
	Motor Rating	kW	
(c)	Materials of Construction		
	Impeller		
	Casing		
	Shaft		

D. Submersible Pump Set (Equalized Sewage Bypass Pump to Municipal Sewer)

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		
	Model		
	Type		
	Quantity (W+S)	Nos.	
(b)	Performance		
	Capacity	cu.m/hr	
	Total head	mlc	

Sl. No.	Description	Units	Particulars
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
(c)	Materials of Construction		
	Impeller		
	Casing		
	Shaft		

E. Nitrifying Liquor Transfer Pumps

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		
	Model		
	Type		
	Quantity (W+S)	Nos.	

Sl. No.	Description	Units	Particulars
(b)	Performance		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
(c)	Materials of Construction		
	Impeller		
	Casing		
	Shaft		

F. Fine Bubble Air Diffusers

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		
	Model		

Sl. No.	Description	Units	Particulars
	Type		
	Diffuser OD x Length	mm x mm	
	Tank Dimensions (L x W x SWD)	mm x mm	
	Design Air-Flow per Tank (Maximum/Average)	Nm ³ /hr	
	Quantity per Aeration/Tank	No.	
	Quantity	No.	
	Weight per Diffuser	Kg	
	Design air flow per diffuser	m ³ /hr	
	Efficiency per diffuser	%	
(b)	Membrane Diffuser		
	Type-self-cleaning (Yes/No)		
	No. of Membranes - Total	No.	
	Membrane Material and Shape		
	Means of attachment		

Sl. No.	Description	Units	Particulars
	Membrane OD X Length	mm x mm	
	Pore size (Average)	mm	
	No. of Pores per length of Diffuser	No./m	
	Bubble size (Avg)	mm	
(c)	Diffuser Assembly		
	Make		
	Type		
	Length x Width	mm x mm	
	Material of Construction		
	Coupling Type • Make • Model/Size		
	Diffuser Assembly Weight	Kg	
(d)	Materials of Construction		
	Diffuser Tube		
	Membrane		

Sl. No.	Description	Units	Particulars
	Pipe clamps & Hardware		
	Pipe Grid		
(e)	Performance		
	SOTE Oxygen transfer rate • Clear water • Field	%	
	Zone of influence	m	
	Zone of oxygenation	m	
	Depth of mixing	m	
	Velocity thro' the Diffuser	m/sec	
	Diffuser Head loss & Efficiency V/s Submergence Curve attached	Yes/No	
	Diffuser Grid Drawing with retrieval arrangement details attached	Yes/No	

G. Air Blowers (Equalisation Tank / Sludge holding tank)

Sl. No.	Description	Units	Particulars
(a)	General		

Sl. No.	Description	Units	Particulars
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Capacity at NTP	m3/min	
	Design maximum discharge pressure	mlc	
	Efficiency	%	
	Speed, blower	rpm	
	Absorbed power	kW	
	Motor rating	kW	
	Speed, motor	rpm	
	Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	With Acoustic Hood	dB(A)	
	Without Acoustic Hood	dB(A)	
	Vibration	mm/sec	
	Weight – Blower	kgs	
	Maximum lifting weight	kgs	

Sl. No.	Description	Units	Particulars
	Dimensions (L x W x H)	m x m x m	
	Coupling Type		
	Coupling Make		
	Cooling System		
(b)	Material of construction:		
	Casing		
	Impeller/Lobes		
	Shaft		
	Common Base frame		
	Orientation		
(c)	Acoustic Hood:		
	Type		
	Material of Construction		
(d)	Inlet/Outlet silencer		
	Type		
	Make		

Sl. No.	Description	Units	Particulars
	Filter media		
	Mean air velocity	m/s	

H. Submersible Mixer

Sl.No.	Description	Units	Particulars
(i)	Make		
(ii)	Model		
(iii)	Type		
(iv)	Quantity (W+S)		
(v)	Motor rating	kW	
(vi)	Motor speed	rpm	
(vii)	Mixer speed	rpm	
(viii)	Impeller material		
(ix)	Shaft material		

I. Air Blowers (Aeration Tank)

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Capacity at NTP	m ³ /min	
	Design maximum discharge pressure	mlc	
	Efficiency	%	
	Speed, blower	rpm	
	Absorbed power	kW	
	Motor rating	kW	
	Speed, motor	rpm	
	Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	With Acoustic Hood	dB(A)	
	Without Acoustic Hood	dB(A)	
	Vibration	mm/sec	

Sl. No.	Description	Units	Particulars
	Weight – Blower	kgs	
	Maximum lifting weight	kgs	
	Dimensions (L x W x H)	m x m x m	
	Coupling Type		
	Coupling Make		
	Cooling System		
(b)	Material of construction:		
	Casing		
	Impeller/Lobes		
	Shaft		
	Common Base frame		
	Orientation		
(c)	Acoustic Hood:		
	Type		
	Material of Construction		
(d)	Inlet/Outlet silencer		

Sl. No.	Description	Units	Particulars
	Type		
	Make		
	Filter media		
	Mean air velocity	m/s	

J. Air Blowers (MBR Tank)

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Capacity at NTP	m ³ /min	
	Design maximum discharge pressure	mlc	
	Efficiency	%	
	Speed, blower	rpm	
	Absorbed power	kW	
	Motor rating	kW	

Sl. No.	Description	Units	Particulars
	Speed, motor	rpm	
	Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	With Acoustic Hood	dB(A)	
	Without Acoustic Hood	dB(A)	
	Vibration	mm/sec	
	Weight – Blower	kgs	
	Maximum lifting weight	kgs	
	Dimensions (L x W x H)	m x m x m	
	Coupling Type		
	Coupling Make		
	Cooling System		
(b)	Material of construction:		
	Casing		
	Impeller/Lobes		
	Shaft		
	Common Base frame		

Sl. No.	Description	Units	Particulars
	Orientation		
(c)	Acoustic Hood:		
	Type		
	Material of Construction		
(d)	Inlet/Outlet silencer		
	Type		
	Make		
	Filter media		
	Mean air velocity	m/s	

K. Rotary Drum Screen

Sl. No.	Description	Units	Particulars
(i)	Quantity		
(ii)	Type		
(iii)	Capacity	cum/hr	
(iv)	Length	m	
(v)	Width m	m	

(vi)	Size of opening	mm	
(vii)	MOC of Screen		
(viii)	Motor power rating	kW	

L. Membrane Bio Reactor

Sl. No.	Description	Units	Particulars
(i)	Membrane Module		
(ii)	Membrane Flux		
(iii)	Flow Direction - Inside - Out arrangement		
(iv)	Flow Direction - Outside - In arrangement		
(v)	Pore Size		
(vi)	Trans-Membrane Pressure		
(vii)	Height required		
(viii)	Head room required		
(ix)	MOC of membrane		
(x)	Operating pH range		
(xi)	Temperature		
(xii)	Cleaning frequency		

(xiii)	Chemical enhance backwash & recovery cleaning		
(xiv)	Configuration		
(xv)	Membrane Material		
(xvi)	Length	M	
(xvii)	Width m	M	
(xviii)	Height	M	
(xviv)	Motor power rating	kW	

M. MBR Permeate Pumps

Sl.NO.	Description	Units	Particulars
(a)	General		
	Make		
	Model		
	Type		
	Quantity (W+S)	No.	
(b)	Performance		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
(c)	Materials of Construction		
	Impeller		
	Casing		
	Shaft		

SI.NO.	Description	Units	Particulars
(g)	Motor :		
	Make		
	Type		
	Model		
	Quantity (W+S)		
	Rating	kW	
	Weight	kgs	
	VFD		

N. MBR Backpulse Pumps

SI.NO.	Description	Units	Particulars
(a)	General		
	Make		
	Model		
	Type		
	Quantity (W+S)	No.	
(b)	Performance		

SI.NO.	Description	Units	Particulars
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
(c)	Materials of Construction		
	Impeller		
	Casing		
	Shaft		
(g)	Motor :		
	Make		
	Type		
	Model		
	Quantity (W+S)		
	Rating	kW	
	Weight	kgs	

Sl.NO.	Description	Units	Particulars
	VFD		

O. NaOCl Dosing System (Disinfection for STP and CTBD ETP)

Sl.No.	Description	Units	Particulars
(a)	Pumps		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	nos	
	(iv) Model		
	(v) Capacity max/min	l/s	
	(vi) Head	m/c	
	(vii) Stroke adjustment	mm	
	(viii) Stroking speed max/min	spm	
	(ix) Casing material		
	(x) Diaphragm material		
	(xi) Shaft material		
	(xiii) Motor rating	kW	
	(xiv) Motor Make		
(b)	NaOCl preparation Tank:		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)		
	(iv) Size (Diameter x Height)	m x m	
	(v) Material of construction		

P. MBR Chemical Cleaning System (NaOCl)

Sl.No.	Description		Units	Particulars
(a)	Pumps			
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	nos	
	(iv)	Model		
	(v)	Capacity max/min	l/s	
	(vi)	Head	mlc	
	(vii)	Stroke adjustment	mm	
	(viii)	Stroking speed max/min	spm	
	(ix)	Casing material		
	(x)	Diaphragm material		
	(xi)	Shaft material		
	(xiii)	Motor rating	kW	
	(xiv)	Motor Make		
(b)	NaOCl preparation Tank:			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)		
	(iv)	Size (Diameter x Height)	m x m	
	(v)	Material of construction		

Q. MBR Chemical Cleaning System (Citric Acid)

Sl.No.	Description		Units	Particulars
(a)	Pumps			
	(i)	Make		

Sl.No.	Description		Units	Particulars
	(ii)	Type		
	(iii)	Quantity (W+S)	nos	
	(iv)	Model		
	(v)	Capacity max/min	l/s	
	(vi)	Head	mlc	
	(vii)	Stroke adjustment	mm	
	(viii)	Stroking speed max/min	spm	
	(ix)	Casing material		
	(x)	Diaphragm material		
	(xi)	Shaft material		
	(xiii)	Motor rating	kW	
	(xiv)	Motor Make		
(b)	Acid preparation Tank:			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)		
	(iv)	Size (Diameter x Height)	m x m	
	(v)	Material of construction		

R. CTBD Effluent Feed Pumps

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		
	Model		

Sl. No.	Description	Units	Particulars
	Type		
	Quantity (W+S)	Nos.	
(b)	Performance		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
	VFD Details		
(c)	Materials of Construction		
	Impeller		
	Casing		
	Shaft		

S. Pressure Sand Filter

Sl. No.	Description	Units	Particulars
i.	Quantity		
ii.	Type		
iii.	Capacity		
iv.	Diameter		
v.	HOS		
vi.	MOC		
vii.	Working and Testing Pressure		
viii.	Media Details		
ix.	Shell Thickness		
x.	Dish Thickness		
xi.	Make		

T. Activated Carbon Filter

Sl. No.	Description	Units	Particulars
i.	Quantity		
ii.	Type		
iii.	Capacity		
iv.	Diameter		
v.	HOS		

Sl. No.	Description	Units	Particulars
vi.	MOC		
vii.	Working and Testing Pressure		
viii.	Media Details		
ix.	Shell Thickness		
x.	Dish Thickness		
xi.	Make		

U. UF System & Its Components

Sr. No.	Item	Unit	Description
(a)	UF System		
	Number		
	Tag nos.		
	Location-Indoor/ outdoor		
	Operation: Continuous / Intermittent		
	Type of Water: Surface / Brackish / Sea / Waste Water / Sewage /Bore Well		
	UF Membrane Type: Sprial Wound / Hollow Fine Fibre		
	Design Feed Flow Rate Per Stream:	M3/Hr	
	Maximum Feed Flow Rate Per Stream:	M3/Hr	
	Feed Water Temperature:	°C	

	Design Permeate Flow Rate Per Stream:	M3/Hr	
	Total System Recovery:	% Minimum	
	UF Membrane Type Of Flow: In To Out / Out To In		
	Type Of Filtration (Operation): Dead End / Cross Flow		
	UF Membrane Material:		
	Membrane Make		
	Molecular Weight Cutoff (MWCO):	DALTONS	
	Design Flux	L/M2/H	
	Membrane Size (Diameter): 4" / 6" / 8", Pore size	Inch, micron	
	Module Orientation: Horizontal / Vertical	micron	
	Back Wash Flux:	Kg/cm2	
	Back Wash With Permeate Water Required		
	Reject Recycle Acceptable		
	Chlorine Tolerance (Max):		
	Pre Filter: Strainer / Basket Filter		
	UF Skids Dimensions & MOC:		
	Air Scouring Required Yes / No:		
	Controls: Micro-Processor / PLC		

	UF PIPING		
	UF Feed Header:		
	UF Reject Header		
	Inter-Stage Header:		
	Permeate Header:		
	Chemical Cleaning		
	Valve MOCs:		
	VICTAULICS:		
	PERFORMANCE GUARANTEE		
	Design Permeate Flow Rate Per Stream:		
	Maximum Permeate Flow Rate Per Stream:		
	Total System Recovery:		
	Total Power Consumption:		
	Chemical Consumption (As 100%)		
	Warranty Duration: Three(3) / Five(5) Years		
	Treated Water Quality		
C)	Bag Filter		
	Make		
	Model		

	Quantity		
	Type		
	Technical specs.		
	Capacity		
	Temperature		
	Operating pressure		
	Design Pressure		
	Pore Size of Fitter		
	No. of Bags / filter housing		
	Inlet size		
	Outlet size		
	MOC of filter housing		

V. UF Feed Pumps

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		
	Model		
	Type		

Sl. No.	Description	Units	Particulars
	Quantity (W+S)	Nos.	
(b)	Performance		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
	VFD Details		
(c)	Materials of Construction		
	Impeller		
	Casing		
	Shaft		

W. UF Backwash Pumps

Sl. No.	Description	Units	Particulars
(a)	General		

Sl. No.	Description	Units	Particulars
	Make		
	Model		
	Type		
	Quantity (W+S)	Nos.	
(b)	Performance		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
	VFD Details		
(c)	Materials of Construction		
	Impeller		

X. UF CIP System

Sl. No.	Description	Units	Particulars
	CIP Solution Tank		
	Quantity:		
	MOC OF CIP SOLUTION TANK:		
	AGITATOR: MOC :		
	CIP PUMP		
	Quantity:		
	Make		
	MOC OF CIP Pump:		
	Capacity / Head		
	Micron Cartridge Filter:		
	Micron Rating		

Y. UF Air Scour Blowers: (Only If Required)

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		

Sl. No.	Description	Units	Particulars
	Type		
	Quantity (W+S)	Nos.	
	Capacity at NTP	m ³ /min	
	Design maximum discharge pressure	mlc	
	Efficiency	%	
	Speed, blower	rpm	
	Absorbed power	kW	
	Motor rating	kW	
	Speed, motor	rpm	
	Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	With Acoustic Hood	dB(A)	
	Without Acoustic Hood	dB(A)	
	Vibration	mm/sec	
	Weight – Blower	kgs	
	Maximum lifting weight	kgs	
	Dimensions (L x W x H)	m x m x m	

Sl. No.	Description	Units	Particulars
	Coupling Type		
	Coupling Make		
	Cooling System		
(b)	Material of construction:		
	Casing		
	Impeller/Lobes		
	Shaft		
	Common Base frame		
	Orientation		
(c)	Acoustic Hood:		
	Type		
	Material of Construction		
(d)	Inlet/Outlet silencer		
	Type		
	Make		
	Filter media		

Sl. No.	Description	Units	Particulars
	Mean air velocity	m/s	

Z. RO FEED PUMPS

Sl. No.	Description	Units	Particulars
(a)	General		
	Make		
	Model		
	Type		
	Quantity (W+S)	Nos.	
(b)	Performance		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
	VFD Details		

Sl. No.	Description	Units	Particulars
(c)	Materials of Construction		
	Impeller		

AA. Micron Cartridge Filter

8.	Micron Cartridge Filter	
i	Make	
ii	Model	
iii	Quantity	
iv	Type	
v	Technical specs.	
vi	Capacity	
vii	Temperature	
viii	Operating pressure	
ix	Design Pressure	
x	Filtration levels	
xi	Filtration media	
xii	Size of cartridge	
xiii	No. of Cartridge/filter housing	
xiv	Inlet size	

xv	Outlet size	
xvi	MOC of filter housing	
8a.	Filter valves	
i	Number	
ii	Diameter	
iii	Type	
iv	Make	
8b.	Pipes & Fittings	
i	Quantity	
ii	Diameter	
iii	Type	
iv	Make	

BB. SMBS Dosing System

Sl. No.	Description	Units	Particulars
(a)	Pumps		
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Model		

Sl. No.	Description	Units	Particulars
	Capacity max/min	l/s	
	Head	mlc	
	Stroke adjustment	mm	
	Stroking speed max/min	spm	
	Casing material		
	Diaphragm material		
	Shaft material		
	Motor rating	kW	
(b)	DOSING TANK		
	Make		
	Model		
	Quantity (W+S)		
	Size (Diameter x Height)	m x m	
	MOC		

CC. pH Correction Dosing System

Sl. No.	Description	Units	Particulars
(a)	Pumps		
	Make		

Sl. No.	Description	Units	Particulars
	Type		
	Quantity (W+S)	Nos.	
	Model		
	Capacity max/min	l/s	
	Head	mlc	
	Stroke adjustment	mm	
	Stroking speed max/min	spm	
	Casing material		
	Diaphragm material		
	Shaft material		
	Motor rating	kW	
(b)	DOSING TANK		
	Make		
	Model		
	Quantity (W+S)		
	Size (Diameter x Height)	m x m	
	MOC		

DD. Anti-Scalant Dosing System

Sl. No.	Description	Units	Particulars
(a)	Pumps		
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Model		
	Capacity max/min	l/s	
	Head	mlc	
	Stroke adjustment	mm	
	Stroking speed max/min	spm	
	Casing material		
	Diaphragm material		
	Shaft material		
	Motor rating	kW	
(b)	DOSING TANK		
	Make		
	Model		
	Quantity (W+S)		
	Size (Diameter x Height)	m x m	

Sl. No.	Description	Units	Particulars
	MOC		

EE.RO System & Its Components

Sr. No.	Item	Particulars
1	System	
i	Operation Hours	
ii	Capacity	
iii	Type of water	
iv	Feed flow	
v	Permeate Flow (Design / Max)	
vi	Array configuration	
vii	Operating Flux	
viii	System Recovery	
ix	Reject Flow	
x	Auto-flushing Requirement Yes / No	
2.	High Pressure Pump	
i	Make	
ii	Model	
iii	Type	

Sr. No.	Item	Particulars
iv	Quantity (W+S)	
v	Capacity	
vi	Differential Head	
vii	Suction head requirement	
viii	Discharge head	
ix	Speed	
x	Overall efficiency	
xi	Impeller MOC	
xii	Casing MOC	
xiii	Shaft MOC	
2a	Motor	
i	Make	
ii	Type	
iii	Model	
iv	Quantity (W+S)	
v	Rating	
vi	Weight	
vii	VFD	
viii	Total Weight of Pump	

Sr. No.	Item	Particulars
3.	Membrane Details	
i	Type of membrane	
ii	Make of Membrane	
iii	MOC Membrane	
iv	Membrane Size and Dia	
4.	Pressure Tubes	
i	Design & Manufacturing Code	
ii	MOC	
iii	Quantity	
iv	Maximum no. of membrane / Tube	
v	Nozzle Type & MOC	
5.	Reject Valve	
i	Reject Valve Operation	Manual /Auto
ii	Reject Valve actuation	Pneumatic /Motorised
iii	Reject Valve type , MOC & rating	
6.	Skid & Piping	
i	RO Skid MOC	
ii	RO Piping MOC	
iii	Feed pipe / header dia	

Sr. No.	Item	Particulars
iv	Permeate pipe / header dia	
v	Reject pipe / header dia	
7.	CIP System	
7a.	CIP Tanks	
i	Quantity	
ii	Make and Model	
iii	Size (Dimensions)	
iv	MOC	
v	Overall Weight	
7b.	CIP Tank Agitator	
i	Quantity	
ii	Make and Model	
iii	Blade Type	
iv	MOC	
v	Overall Weight	
vi	Agitator Motor Speed / Rating	
vii	Support MOC	
7c.	CIP Pumps	

Sr. No.	Item	Particulars
i	Quantity	
ii	Make and Model	
iii	Type	
iv	Capacity (Min/Max)	
v	Pressure	
vi	Stroke adjustment	
vii	Stroke speed	
viii	Casing Material	
ix	Diaphragm Material	
x	Motor Rating	
xi	Motor Make	
8.	Micron Cartridge Filter for CIP	
i	Make	
ii	Model	
iii	Quantity	
iv	Type	
v	Technical specs.	
vi	Capacity	
vii	Temperature	

Sr. No.	Item	Particulars
viii	Operating pressure	
ix	Design Pressure	
x	Filtration levels	
xi	Filtration media	
xii	Size of cartridge	
xiii	No. of Cartridge/filter housing	
xiii	Inlet size	
xiv	Outlet size	
xv	MOC of filter housing	
8a.	Filter valves	
i	Number	
ii	Diameter	
iii	Type	
iv	Make	
8b.	Pipes & Fittings	
i	Quantity	
ii	Diameter	
iii	Type	
iv	Make	

Sr. No.	Item	Particulars
9.	Instrumentation & Control Provided	Contractor to indicate numbers and locations
i	pH Meter	
ii	ORP Meter	
iii	DPT	
iv	Pressure Switches	
v	Temp. indicator	
vi	Conductivity meter	
vii	Flow Meter	
10.	Performance Guarantee	
i	System recovery	
ii	Permeate flow	
iii	RO feed pressure	
iv	Permeate Quality (pH, TDS, Hardness)	
v	Reject	
vi	Total Load of RO system, KW	
vii	Membrane Warranty (years)	
11.	Essential Spares	

Sr. No.	Item	Particulars
i	Victaulics -25%	Provided : Yes / No
ii	Brine seals – 25%	Provided : Yes / No
iii	End cap assembly-2 nos.	Provided : Yes / No
iv	Permeate ports – 25%	Provided : Yes / No
v	Permeate Plugs -25%	Provided : Yes / No
vi	Permeate Hoses -25%	Provided : Yes / No
vii	Reject Valve -1 no.	Provided : Yes / No
viii	'O' ring of all sizes – 100%	Provided : Yes / No
12.	Enclosures with Bid	
i	Projection @ 25°C 3 years	Enclosed : Yes / No
ii	GA drawing of skid	Enclosed : Yes / No
iii	GA drawing of all components	Enclosed : Yes / No

FF. RO Permeate Pumps

Sl.No.	Description		Units	Particulars
(a)	General			
	(i)	Make		
	(ii)	Model		

Sl.No.	Description		Units	Particulars
	(iii)	Type		
	(iv)	Quantity (W+S)	No.s	
(b)	Performance			
	(i)	Capacity	cu.m/hr	
	(ii)	Total head	mlc	
	(iii)	Speed	rpm	
	(iv)	Overall efficiency (Pump + Motor)	%	
	(v)	Motor Rating	kW	
(c)	Materials of Construction			
	(i)	Impeller		
	(ii)	Casing		
	(iii)	Shaft		
(g)	Motor :			
	(i)	Make		
	(ii)	Type		
	(iii)	Model		

Sl.No.	Description		Units	Particulars
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

GG. Dewatering Poly Dosing System

Sl.No.	Description		Units	Particulars
(a)	Pumps			
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	nos	
	(iv)	Model		
	(v)	Capacity max/min	l/s	
	(vi)	Head	mlc	
	(vii)	Stroke adjustment	mm	
	(viii)	Stroking speed max/min	spm	
	(ix)	Casing material		
	(x)	Diaphragm material		

Sl.No.	Description		Units	Particulars
	(xi)	Shaft material		
	(xiii)	Motor rating	kW	
	(xiv)	Motor Make		
(b)	PE preparation Tank:			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)		
	(iv)	Size (Diameter x Height)	m x m	
	(v)	Material of construction		

HH. Centrifuge

Sl. No.	Description	Unit	Contractor To Indicate
(a)	General		
(i)	Manufacturer		
(ii)	Type		
(iii)	Model		
(iv)	Quantity	No.s	
(v)	Feed rate per centrifuge	m ³ /hr	
(vi)	Dewatered sludge cake thickness		
(vii)	% dried solids		
(viii)	Noise level (dBA) at 1m	dB(A)	

Sl. No.	Description	Unit	Contractor To Indicate
(ix)	Vibration level		
(x)	Feed pressure required	Kg/cm2	
(xi)	Bowl Diameter	mm	
(xiii)	Bowl length	mm	
(xiv)	Taper Angle	degrees	
(xv)	Bowl speed	rpm	
(xvi)	Centrifugal force	N	
(xvii)	Gear Box ratio		

II. Piping

Sl. No.	Description	Particulars
Sewage/Sludge & Treated Sewage piping Data		
1	Quantity	
2	MOC	
3	Pressure	
4	Make	
Air piping Data		
1	Quantity	
2	MOC	
3	Class	

Sl. No.	Description	Particulars
4	Make	
Chemical Dosing Piping Data		
1	Quantity	
2	MOC	
3	Class	
4	Make	

Motor Operated Hoists And Trolleys

Sl.No.	Description		Units	Particulars
(a)	(i)	Manufacturer		
	(ii)	Type and class		
	(iii)	Model		
	(vi)	Safe working Load	tonne	
	(v)	Span	metres	
	(vi)	Lift	metres	

JJ. Valves

S. No.	Item	Description	Unit	Particulars
(a)		Butterfly valves :#		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	bar	
	(viii)	Test pressure	bar	
	(ix)	Body material		
	(x)	Disc material		
	(xi)	Sealing face material		
	(xii)	Shaft material		
	(xiv)	Gear Reducers		
	(xv)	Manufacturer		
	(xvi)	Material		

S. No.	Item	Description	Unit	Particulars
	(xvii)	Flange Drilling standard		
(b)		Butterfly Valve Actuators #		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity	Nos.	
	(vi)	Motor rating	kW	
	(vii)	Design Torque	N-m	
	(viii)	Time for full open to full close	minutes	
(c)		Non-return valves #		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		

S. No.	Item	Description	Unit	Particulars
	(v)	Quantity	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	bar	
	(viii)	Test Pressure	bar	
	(ix)	Design standard		
(d)		Material of construction:		
	(i)	Body		
	(ii)	Disc/plates		
	(iii)	Spring		
	(iv)	Shaft		
	(v)	Flange drilling standard		
(e)		Sluice valves :#		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		

S. No.	Item	Description	Unit	Particulars
	(v)	Quantity	Nos	
	(vi)	Size	mm	
	(vii)	Rating	kg/cm ²	
	(viii)	Test pressure	kg/cm ²	
	(ix)	Body material		
	(x)	gate material		
	(xi)	Sealing face material		
	(xii)	Shaft material		
	(xiv)	Gear Reducers :		
	(xv)	Manufacturer		
	(xvi)	Material		
	(xvii)	Flange Drilling standard		
(f)		Sluice Valve Actuators #		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Quantity	Nos	

S. No.	Item	Description	Unit	Particulars
	(iv)	Motor rating	kW	
	(v)	Design Torque	N-m	
	(vi)	Time for full open to full close	minutes	
(g)		Knife Gate valves :#		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity	Nos	
	(vi)	Size	mm	
	(vii)	Rating	kg/cm2	
	(viii)	Test pressure	bar	
	(ix)	Body material		
	(x)	gate material		
	(xi)	Sealing face material		
	(xii)	Shaft material		

S. No.	Item	Description	Unit	Particulars
	(xiv)	Gear Reducers :		
	(xv)	Manufacturer		
	(xvi)	Material		
	(xvii)	Flange Drilling standard		
(h)		Knife Gate Valve Actuators #		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Number		
	(iv)	Motor rating	kW	
	(v)	Design Torque	kg-m	
	(vi)	Time for full open to full close	minutes	

Bidder to provide above details for each size, type of Valve and Service.

INSTRUMENTATION & CONTROL SYSTEM**1. Pressure Indicator:**

1.	1.0 GENERAL	
2.	MANUFACTURER :	*
3.	MODEL NO.:	*
4.	2.0 TYPE	
5.	3.0 SENSOR TYPE: BOURDON ☒	✓
6.	DIRECT READING ☒ RECEIVER ☐	✓
7.	GLYCERIN FILLED: YES ☒ NO ☐	✓
8.	WITH SWITCHING CONTACTS : YES ☐ NO ☒ HI ☐ LO ☐	x
9.	CHEMICAL DIAPHRAGM SEAL : DIRECT MOUNTING ☒ REMOTE WITH CAPILLARY ☒ CAPILLARY LENGTH : 10 mtr FILL FLUID : SILICON	✓
10.	MOUNTING : DIRECT ☒ SURFACE ☐ PANEL ☐	✓
11.		
12.	<u>FEATURES:</u>	
13.	DIAL SIZE: 150 MM ☐ 100 MM ☒	✓
14.	ACCURACY : +/- 1% of FS or better	✓
15.	OVER RANGE PROTECTION : 130% of full range	✓
16.	BLOW OUT DISC :	✓
17.	4.0 ENCLOSURE PROTECTION	
18.	5.0 FOR PRESSURE INDICATOR WITH SWITCHING CONTACTS: 6.0 WEATHER PROTECTION: IP 65 ☒ EX-PROOF TO ZONE __ ☐ GROUP IIA ☐ IIB ☐ IIC ☐ TEMPERATURE CLASS :	✓
19.	7.0 SWITCH DETAILS: NO. OF CONTACTS : 2 NO + 2 NC ☐ 2 CHANGEOVER ☐ CONTACT RATING :	x
20.	8.0 MATERIAL OF CONSTRUCTION	
21.	9.0 HOUSING: DIE CAST ALUMINIUM ☒	✓
22.	10.0 PRESSURE ELEMENT: 11.0 SS 316 ☒ NEOPRENE DIAPHRAGM ☐ PTFE COATING ☐ PHOSPHOR BRONZE ☐	✓
23.	MOVEMENT : SS 316 ☒ SS 304 ☐	✓

24.	12.0 SOCKET : SS 316 ☒ SS 304 ☐	✓
25.	13.0 GLASS SHATTERPROOF ☒	✓
26.	CHEMICAL DIAPHRAGM SEAL : SS316 ☒ HASTELLOY ☐ TANTALUM ☐	✓
27.	14.0 CONNECTION & DIMENSIONS	
28.	15.0 PROCESS CONNECTION: THREADED ☒ 16.0 FLANGED ☐	✓
29.	17.0 THREADED PROCESS CONNECTION: 18.0 ½ "NPT (M) ☒ ¼ " NPT (M) ☐ 1" NPT (M) ☐	✓
30.	19.0 FLANGED PROCESS CONNECTION: FLANGE RATING : FLANGE SIZE :	*
31.	20.0 PROCESS CONNECTION LOCATION: BOTTOM ☒ BACK ☐	✓
32.	21.0 CABLE ENTRY: ½" NPT (F) ☐ ☐	x
33.	22.0 ACCESSORIES (REFER NOTE 3)	

34.	NAME PLATE / METAL TAG : (Refer note 6)	✓
35.	23.0 MOUNTING BRACKET:	✓
36.	SYPHON : (Refer note – 4)	✓
37.	SNUBBER : (Refer note – 4)	✓
38.	2 VALVE MANIFOLD : ☐ BLOCK & BLEEDS ☐ ISOLATION VALVE : ☒	✓
39.	ALL INSTALLATION HARDWARE	✓
40.	24.0 CODES AND STANDARDS (REFER NOTE 2)	
41.	SPECIFICATIONS – IS 3624	✓
42.	SELECTION & INSTALLATION – BS EN 837	✓
43.	WEATHER PROOF – IS 13947 PART I	✓
44.	EXPL. PROOF–IS 2148/ BS EN 50014/ BS EN 50020	✓
45.	<u>TESTS :</u>	
46.	CALIBRATION : Required	✓
47.	HYDRO TEST : Required at 1.5 times the max pressure	✓
48.	REPEATABILITY : Required	✓

Notes:

- 1.0 (*) - Bidder to furnish details; (✓) – required; (x) – not required / not applicable
- 2.0 The bidder shall indicate all applicable codes and standards.
- 3.0 All accessories required to make the installation complete shall be supplied by bidder.
- 4.0 Following details minimum shall be available on the tag plate:-
- Tag number, manufacturer's name or trademark.
 - Model number, serial number, pressure & temperature rating.
 - Diaphragm material.
 - Process connection/rating.
 - Operating pressure & range values.

2. Pressure Indicating Transmitter:

49.	<u>GENERAL</u>	
50.	Manufacturer:	
51.	Model no.:	
52.	<u>FEATURE</u>	
53.	Type: Microprocessor based Smart (2-wire) ,indicating	✓
54.	Mounting: pipe mounted ☒	✓
55.	External Zero and Span adj.: Required	✓
56.	Accuracy: ± 0.075% of span	✓
57.	Over range Protection: 130% of full range	✓
58.	Stability: ±0.125% of FSR for minimum 5 years	✓

59.	Operation Principle:	*
60.	Display: Backlit LCD with Engineering units	
61.	SIL ____ compliance ☐ SIL Not required ☒	X
62.	Isolation Min : 500Vac & EMC compatibility as per EN 61326	✓
63.	<u>ENCLOSURE</u>	
64.	Case protection class: IP-65	✓
65.	Case Colour: Grey ☒ Black ☐	*
66.	Area classification: Zone 0 ☐ 1 ☐ 2 ☐ ; Group IIA ☐ IIB ☐ IIC ☐ ; TEMP. CLASS T1 ☐ T2 ☐ T3 ☐ T4 ☐ T5 ☐ T6 ☐ Refer follow up sheet (Refer note 3)	X
67.	Intrinsic safe certified: For Hazardous area	X
68.	<u>SUPPLY / SIGNAL</u>	
69.	Power Supply: 24V DC	✓
70.	Output signal: 4-20mA HART ☒	✓
71.	<u>MATERIAL</u>	
72.	Housing: Aluminum with epoxy coating	✓
73.	Body: SS	✓
74.	Sensing Element: SS 316 ☒	✓
75.	Diaph. Seal / Body: SS 316 ☒	✓
76.	Capillary and Armour: SS 316	✓
77.	Fill fluid : (Refer note -7)	X
78.	Wetted part: Refer follow-up sheet	X

79.	<u>CONNECTIONS & DIMENSIONS</u>	
80.	Process Conn: Flanged ☒	✓
81.	Process conn. details: Refer follow-up sheet	X
82.	Location: Bottom ☒ Back ☐	*
83.	Cable entry : ½" NPT(F) (2 nos.) with SS double compression type cable glands with PVC shroud. Spare entry shall be plugged with SS plug.	✓
84.	<u>ACCESSORIES</u> (Refer note-4)	
85.	Name Plate: Removable - SS	✓
86.	Mounting Bracket: SS (2" pipe bracket)	✓
87.	Diaphragm Seal : Refer follow-up sheet	✓
88.	Armoured Capillary – Refer follow-up sheet	✓
89.	2 Valve manifold: SS	✓
90.	Flushing ring : SS	✓
91.	Syphon: Refer follow-up sheet	✓
92.	Snubber: Refer follow-up sheet	✓
93.	Application : Raw Water	✓

1.0	(*) - Bidder to furnish details; (✓) - Required; (x) - Not required / Not applicable.
2.0	Intrinsic Safe Instruments if provided for instruments located in hazardous areas shall comply with relevant hazardous area classification codes.

3.0	All accessories shall be supplied as specified. In addition, any other accessories required to make the installation complete shall be supplied without any cost implication.
4.0	Chemical seal diaphragm shall be used when the fluid is corrosive or viscous. All wetted parts for sea water application shall be of SS316L with COMPLIANCE TO NACE-MR-01-75 (latest edition).
5.0	Field bus / Profibus PA based transmitter shall meet following requirement All instrument must satisfy the requirement of field bus registration laboratory with applicable check marks like foundation field bus, profibus PA or as specified. All instrument shall have two analog input block as minimum. In addition when specified the transmitter shall also have PID controller block, arithmetic block, Input selector and signal characterizer block shall be provided All instrument must be interoperable and shall have valid interoperability test clearance like ITK 4.6 for foundation field or equivalent for profibus PA as applicable. The field bus instrument shall support peer to peer communication.
6.0	Fill fluid selection shall be suitable for process fluid temperature and for hygiene application such as Food, Parma and Beverage.
7.0	For pressure transmitter, the normal operating pressure shall be within 40% to 70% of the calibrated scale range. The selected range shall be subjected to purchaser/ consultant approval.

3. Electromagnetic Flow Meter :

1.	25.0 GENERAL	
2.	Manufacturer :	*
3.	Model no.:	*
4.	Quantity:	**
5.	Tag no	**
6.	Area classification: ZONE 0 ☐ 1 ☐ 2 ☐ ; GROUP IIA ☐ IIB ☐ IIC ☐ ; TEMP. CLASS T1 ☐ T2 ☐ T3 ☐ T4 ☐ T5 ☐ T6 ☐	X
7.	Weather protection class: IP 65 ☒ IP 66 ☐	✓

8.	Ex-Proof : Exd ☐	✓
9.	SIL Level (Note-7): Required as minimum SIL-__ as per IEC 61508 & IEC 61511 Required ☐ Not Required ☐	
10.	Accuracy : Better than +/- 0.5% of flow rate	✓
11.	Repeatability : ±0.25% of reading	✓
12.	Automatic zero provision	✓
13.	Online electrode cleaning arrangement: Refer Note- 6	✓

14.	Maximum permissible cable distance between flow tube and transmitter: 5 Meter ☒	✓
15.	Empty tube detection: Required ☒	✓
16.	Rangeability:	*
17.	26.0 <u>PROCESS DATA</u>	**
18.	27.0 <u>FLOW TUBE</u>	
19.	Process connection : Flanged	✓
20.	Electrical connections : ½" NPTF	✓
21.	28.0 Electrode type: EMF Meter ☒	✓
22.	29.0 Liner: Required ☒	
23.	30.0 Grounding type: Grounding Ring ☒ Grounding Electrode ☐	✓
24.	31.0 Coil insulation: Class F suitable for high temperature as per IEC60085 / IS 1271	✓
25.	32.0 <u>MATERIAL OF CONSTRUCTION</u>	
26.	33.0 Metering tube: SS316	✓
27.	34.0 Liner: Teflon ☐ PTFE ☐ PFA ☐ Hard Rubber ☒	✓
28.	35.0 Electrodes:	**
29.	36.0 Flanges:	**
30.	37.0 Coil housing: Di Cast Al ☒	✓
31.	38.0 Jacket: Required ☒ Not Required ☐	✓
32.	39.0 Converter/ electronic housing: Di Cast Al	✓

33.	40.0 <u>FLOW TRANSMITTER</u>	
34.	Mounting: Integral ☒ Separate ☒	✓
35.	Type of transmitter: 4 Wire ☒	✓
36.	Display on transmitter : Flow Rate ☒ Flow Totalizer ☒	✓
37.	Type of display: LED ☐ Backlit LCD ☒ LCD ☐	✓
38.	Battery backup for flow totalizer : Required ☐	✓
39.	Power supply : Power Supply (four wired) : 24V DC ☒ Power Supply (for wireless) : Easy to replace Lithium batteries (Note – 10) ☐	✓
40.	Output signal: 4-20mA HART ☒ Fieldbus ☐ Profibus PA ☐ Wireless ☐	✓
41.	Alarms : Hi ☐ Low ☐	x
42.	No. and type of contacts : 1 No SPDT ☐ 1 No DPDT ☐	x
43.	Contact rating : 2A@24VDC ☐	
44.	41.0 Material of housing: Di Cast Al ☒	✓
45.	Maximum load: >500 Ohms	✓
46.	Cable entry : ½" NPT (4 Nos) with Double compression cable gland	✓
47.	Diagnostic information :	✓
48.	Reverse flow :	✓
49.	Transmitter fault :	✓

50.	Coil circuit fault :	✓
51.	Ground/wiring fault (applicable for slurry application)	✓
52.	High process noise (applicable for slurry application)	✓
53.	42.0 WIRELESS TRANSMITTER	x
54.	Transmitter update rate : Selectable between 4 sec to 60 sec	
55.	Battery Voltage and Drain time:	x
56.	Battery life: Min. 2yrs with 4 sec. update rate or better (Note-8)	x
57.	Antenna type : Integrated Omni directional Antenna ☐ Remote mount Omni directional Antenna ☐	x
58.	Signal Range: Minimum 200m or better without any repeater & with clear line of sight	x
59.	Wireless Frequency : 2.4GHz license free ISM Band	x
60.	Radio security : AES 128 bit encryption	x
61.	Wireless Protocol: ISA 100.11a (IEC 62734) / Wireless HART (IEC62591-1)	x
62.	Transmitter Configuration : via gateway over wireless network	x

63.	Device programming: Transmitter to work as input device, repeater and Access point	x
64.	Network: Note-9	x
65.	<u>ACCESSORIES</u>	
66.	Spool piece for start-up use	✓
67.	Matching flanges, nuts and bolts	✓
68.	Name plate/ metal tag	✓
69.	Cable between flow tube and transmitter unit: Required ☒ Not Required ☐	
70.	Remote flow indicator & integrator : Required ☒ Not Required ☐	
71.	Mounting brackets : Required ☒ Not Required ☐	
72.	<u>CODES AND STANDARDS</u>	
73.	Test and calibration : IEC 17025	✓
74.	Ex-Proof protection : IEC 60079	✓
75.	Weather protection class : IEC 60529	✓
76.	EMC requirement: IEC 61326-1	✓
77.	Shock & vibration Resistance: IEC 60068-2-6	✓
78.	<u>TESTS</u>	

79.	Calibration test certificate: 5 Points Calibration ☒	✓
80.	Hydrostatic:	✓

81.	Test certificate from CMRI / ERTL for equipment manufactured in India	✓
82.	Certificate of conformity from LCIE, BASEEFA, PTB, CSA, UL, ATEX for equipment manufactured outside India	✓

Notes:

1. (*) - Bidder to furnish details; (✓) - Required; (x) - Not required / Not applicable.
2. The bidder shall indicate all applicable codes and standards.
3. The velocity limits to be considered for meter sizing shall be as mentioned below
 - a) For slurries and viscous flow: 4 to 5 m/s
 - b) For all other service: 2 to 3 m/s

Velocities beyond these limits shall not be considered.
4. Field bus based transmitter shall meet following requirement
 - a) All instruments must satisfy the requirement of field bus registration laboratory with applicable check marks like foundation field bus, Profibus PA or as specified.
 - b) All instruments shall have two analog input blocks as minimum. in addition when specified the transmitter shall also have PID controller block
 - c) All instruments must be interoperable and shall have valid interoperability test clearance like ITK 4.6 for foundation field or equivalent for PA as applicable.
 - d) The field bus instrument shall support peer to peer communication.
 - e) Field bus instrument offered shall not be polarity sensitive
5. The configuration data for the instrument shall be stored in non volatile memory.
6. Whenever process fluid has coating characteristics, where cleaning of electrode is necessary because of coating, vendor shall offer online removable electrode.
7. TUV / EXIDA certification as per IEC 61508 & IEC 61511 for SIL rated flow transmitters shall be provided by vendor. Vendor to provide safety manual as per IEC 61508 for all the applicable tags which shall contains at least.

- a) SIL rating, HFT value, Device Type, Mode of operation
- b) Safety parameters: β , β_D , λ_{DU} , λ_{DD} , λ_{SU} , λ_{SD} , PTR, MTBF, MTTR, DC, PFD, SFF, RRF
- c) Possible design / architectural constraints
8. All the transmitters supplied for wireless network shall come with same type of batteries so that spare maintenance could be easier (These batteries should be compatible for all the models of Pressure, Temperature, Adaptor supplied in this network) Transmitter shall be supplied with battery removed during shipping.
 9. Wireless connectivity and all devices shall be pre configured / field configurable with Mesh / Star / combination of both topologies with all devices configured as Transmitter, repeater based on application requirement.
 10. Adapter is required for converting an existing wired transmitter to wireless complying with IEEE 802.154.
 11. Self diagnostics features such as Sensor Failure, amplifier failure, configuration error, battery alarm, and wireless communication alarm and over-range error for process variables.

4. On-Line Turbidity/ TSS Meter :

1.	43.0 GENERAL	✓
2.	MANUFACTURER:	*
3.	MODEL NO.	*
4.		
5.	<u>FEATURES</u>	
6.	<u>SENSOR</u>	✓
7.	TYPE : OPTICAL SENSOR	✓
8.	MEASURING PRINCIPLE : RATIO-METRIC ☒ ☐	*
9.	SENSITIVITY : 0.2 NTU OR +/- 2.0 % OF READING ☒ ☐	✓
10.	CLEANING FACILITY : WIPER ☒	✓

11.	COLOUR COMPENSATION :	✓
12.	RANGE SETTING: SELECTABLE TURB: 0-1, 0-10, 0-100 NTU ☒ TSS: 0-10, 0-1000, 0-5000 PPM ☒	✓
13.	TYPE OF LIGHT SOURCE : TUNGSTEN LAMP ☐ LED ☒ ☐	✓
14.	INTEGRAL CABLE CONNECTING SENSOR AND TRANSMITTER	✓
15.	<u>TRANSMITTER</u>	✓
16.	MICROPROCESSOR BASED :	✓

33.		
34.	44.0 MATERIAL of CONSTRUCTION	
35.	TRANSMITTER ENCLOSURE : NON-CORROSIVE	*
36.	WETTED PARTS : NON- CORROSIVE	*
37.		
38.	45.0 ACCESSORIES (REFER NOTE 3)	✓
39.	NAME PLATE / METAL TAG	✓
40.	BUBBLE TRAP	✓
41.	SAMPLING SYSTEM COMPRISING OF : SAMPLING PUMPS, ROTAMETER, STRAINER, ADJUSTMENT VALVE ETC. (REFER NOTE 5) PRESSURE REDUCING VALVE, ROTAMETER, STRAINER, ADJUSTMENT VALVE ETC. (REFER NOTE 6) SAMPLE FLOW RATE PRESSURE	* *
42.	STANDARD GLASS CUBE OR FORMAZINE SOLUTION FOR CALIBRATION	✓
43.	DIGITAL PANEL METER (REFER NOTE 4)	x
44.	ALL INSTALLATION HARDWARE	✓
45.		
46.	46.0 CODES & STANDARDS (REFER NOTE 2)	✓

47.	WEATHER PROOF : IS 13947 - PART I	✓
48.		
49.	<u>TESTS</u>	✓

50.	PERFORMANCE	✓
51.	CALIBRATION	✓
52.	HYDRO TEST	✓

NOTES :

1.0 * Bidder to state.

2.0 The bidder shall indicate all applicable codes and standards.

3.0 All accessories shall be supplied as applicable.

4.0 Detailed specifications for this item is given separately.

5.0 Sampling system comprising of sampling pumps, rotameter, strainer adjustment valve etc. Shall be provided where the sample is to be taken from an open channel or from an unpressurised line.

6.0 Sampling system comprising of pressure reducing valve, rotameter, strainer, adjustment valve etc. Shall be provided where the sample is to be taken from a pressurised line.

7.0 A mounting rack shall be provided for mounting of strainer, rotameter, adjustment valve, sensor holder flow through assembly, transmitter etc.

5. pH Analyser

1.	<u>GENERAL.</u>	
2.	MANUFACTURER :	*
3.	MODEL NO. :	*
4.	QUANTITY & RANGE :	✓
5.	<u>SENSOR</u>	
6.	ELECTRODES [COMBINED pH ELECTRODE AND REFERENCE	✓

	ELECTRODE] & INTEGRAL TEMP. COMPENSATOR ASSY	
7.	TYPE : FLOW THROUGH TYPE ☐ SUBMERSION ☒ INSERTION ☐	✓
8.	PRESSURE LIMITATION :	✓
9.	TEMPERATURE LIMITATION :	*
10.	TEMP. COMPENSATING ELEMENT :	*

11.	SENSOR CLEANING: AUTOMATIC CLEANING WATER JET ☐ ULTRASONIC CLEANING ☒	✓
12.	DETACHABLE CABLE AT CELL	✓
13.	<u>ANALYZER</u>	✓
14.	TYPE : MICROPROCESSOR BASED	✓
15.	DISPLAY : BACKLIT LCD DISPLAY ☒ LED ☐	✓
16.	ACCURACY :	✓
17.	AMBIENT TEMP. :	✓
18.	AMBIENT HUMIDITY :	✓
19.	MOUNTING : PANEL ☐ WALL ☒ PIPE ☐	✓
20.	TEMPERATURE COMPENSATION: AUTO ☒ MANUAL ☐	✓
21.	CALIBRATION CHECK : AUTO ☒ MANUAL ☐	✓
22.	INBUILT SLOPE CALCULATION (REF. NOTE – 3)	✓
23.	INTEGRAL ISOPOTENTIAL ADJUSTMENT	✓
24.	ENCLOSURE PROTECTION :	✓
25.	SELF DIAGNOSTIC FEATURES (REF. NOTE – 4)	✓
26.	<u>MATERIAL</u>	
27.	ELECTRODE MATERIAL : GLASS	✓

28.	ELECTRODE BODY & HOLDER MATERIAL: PP ☒ SS316 ☐ OTHERS ☐	✓
29.	GASKET & 'O'RINGS : 'VITON' ☒ OTHERS ☐	✓
30.	ENCLOSURE: DIE CAST ALUMINIUM ☒ ABS PLASTIC ☐ OTHERS ☐	✓
31.	<u>SUPPLY/SIGNAL</u>	
32.	POWER SUPPLY : 240V AC ☒ 24V DC ☐	✓
33.	OUTPUT : 4-20mA ☒ HART ☐	✓
34.	ALARM CONTACTS : HI ☐ LO ☐	x
35.	NO OF CONTACTS : SPDT 2 nos.	x
36.	CONTACT RATING : 5 A, 240 VAC ☐ 5A, 24 VDC ☐	x
37.	<u>CONNECTIONS & DIMENSIONS</u>	
38.	FOR CELL : 1"NPT ☐ 3/4"NPT ☐ 1 1/2 "NPT ☐	*
39.	CONDUIT SIZE AT ANALYSER : 1/2" NPT fittings with SS-316 gland	✓
40.	TERMINAL : REF. NOTE 7	✓
41.	<u>ACCESSORIES</u>	
42.	MOUNTING BRACKETS	✓
43.	NAME PLATE : SS316	✓

44.	METAL TAGS : SS316	✓
45.	JUNCTION BOX FOR ELECTRODE ASSY : REFER BOM	✓
46.	INTEGRAL PREAMPLIFIER: REFER BOM	✓
47.	GROMMETS & WASHERS	✓
48.	INTER CONNECTING CABLES BETWEEN CELL AND ANALYSER	✓

49.	ONE BOTTLE EACH OF BUFFER TABLETS FOR 4 pH & 9.2 pH	✓
50.	<u>CODES & STANDARDS</u>	
51.	Enclosure Protection: IEC 60529	✓
52.	ASTM D1293	✓
53.	ASTM D1129	✓
54.	ASTM D3370	✓

Notes:

1.0	* Bidder to state.
2.0	Applicable if auto calibration is selected.
3.0	Fault diagnosis data shall include faults in analogue / digital circuits, faults in calibrated values, and power supply failure.
4.0	Each ph analyser shall be supplied as a complete system. purchaser's terminal points are only the root valves at the pipes, drain headers, plant cooling water header, chilled cooling water header and cable termination at the analyser panel for purchaser's use.
5.0	Any accessories other than specified and are required for the functioning of the system ~~shall also be supplied along with the equipment~~
6.0	Terminal size shall be suitable to accept 0.5sq. Mm cable for signals and 1.5/2.5sq.mm cable for power supply.

6. ORP Analyser

Sr. No.	Description	Employer's requirement
	GENERAL	
1.	Manufacturer	*
2.	Model No.	*
	FEATURE	
3.	Measuring principle	Metal electrode method
4.	Type	Flow through
5.	Measurement	Continuous
6.	Measuring range	- 1500 mV to + 1500 mV
7.	Accuracy	± 2% of FSD
8.	Repeatability	± 0.3% of span
9.	Pressure limitation	*
10.	Temperature limitation	*
11.	Temperature compensation range	Same as operating temperature range
12.	Temperature compensating element	Pt 100 integral to cell
13.	Analyser unit with HMI	Required
14.	Circuits	Microprocessor based
15.	Auto zero check	Required

16.	Manual zero and calibration check	Required
17.	Electrode housing	IP 65
18.	Analyser housing	IP 65 with corrosion proof casing
19.	Display	Integral display
	MATERIAL OF CONSTRUCTION	
20.	Electrode Body	Ryton
21.	Measuring surface	Platinum or gold
22.	Holder	SS 316
	SUPPLY/ SIGNAL	
23.	Power supply	110 V AC, 1Ph, 50Hz
24.	Output	Isolated 4-20 mA DC
25.	HI & LO alarm contact	Changeover, pot free, 2 contacts per alarm
26.	Analyser fault annunciation contact	Required
27.	Contact rating	0.2A, 220 V DC
28.	Preamplifier	Required
29.	Inter connecting cables between cell and analyser	Required
	CONNECTION & DIMENSIONS	
30.	For cell	*
31.	Conduit size	1" ET

32.	Sample/ drain connection	¼ " NPT
33.	Name plate/ metal tag	Fixed SS304
	Installation hardware	Required

7. On-Line Residual Chlorine Measurement

1.	47.0 GENERAL	
2.	Manufacturer:	*
3.	Model no.	*
4.	Tag No:	*
5.	Quantity :	*
6.	Area classification: Zone 0 ☐ 1 ☐ 2 ☐ ; Group IIA ☐ IIB ☐ IIC ☐ ; Temp. Class T1 ☐ T2 ☐ T3 ☐ T4 ☐ T5 ☐ T6 ☐	x
7.	<u>ENCLOSURE PROTECTION</u>	✓
8.	Weather protection class: IP 65 ☒ IP 66 ☐	✓
9.	Ex-Proof : Exd ☐	x
10.	<u>PROCESS DATA</u>	*
11.	<u>FEATURES</u>	✓
12.	<u>SENSOR</u>	✓
13.	Type : Amperometric ☐ Colorimetric ☐	*
14.	Sensitivity : 0.05 PPM ☐ 0.005 PPM ☒	✓
15.	Response time :	*
16.	Integral cable connecting sensor & transmitter	✓
17.	Operating life :	*
18.	Ambient temperature : 0° C to 60° C	✓
19.	<u>TRANSMITTER</u>	✓
20.	48.0 Type of microprocessor based transmitter: 2 Wire ☐ 4 Wire ☐	*
21.	Integral display : Backlit LCD ☒ LED ☐	✓
22.	Zero & Span adjustment :	✓
23.	Automatic temperature compensation :	✓
24.	Automatic pH compensation :	✓
25.	Overall accuracy of measurement loop : ±2% of reading ☒	✓
26.	Mounting : Panel ☐ Field ☒ Rack ☐	✓
27.	Inlet/ Outlet connection :	*
28.	Calibration interval :	*
29.	Calibration method :	*
30.	Self-diagnostic features :	✓
31.	<u>SIGNAL & POWER SUPPLY DETAILS</u>	✓
32.	Power supply : 24V DC ☐ 110 VAC ☐ 230 VAC ☒ Power Supply (for wireless) : Easy to replace Lithium batteries (Note – 10) ☐	✓
33.	Output signal : 4-20 mA HART Loop Power ☒ Field Bus ☐ Modbus RS-485 ☐ Wireless HART ☐ Wireless ISA 100.11a ☐	✓
34.	<u>ALARM SWITCH DETAILS</u>	x
35.	Alarms : Yes ☐ No ☐ HI ☐ LO ☐ Fault ☐	x

36.	No. and type of contacts: 1 No SPDT ☐ 1 No DPDT ☐	x
37.	Contact rating: 5A@ 230 V AC ☐ 2A@24VDC ☐	x
38.	49.0 MATERIAL OF CONSTRUCTION	✓
39.	Measurement electrode (cathode) : platinum ☐ gold ☐	*
40.	Reference electrode (anode) : Silver ☐ Copper ☐	*
41.	Wetted parts : SS316 ☒ PVC ☐ polycarbonate ☐	✓
42.	Transmitter enclosure : ABS plastic ☐ Epoxy coated die cast aluminium ☒ Epoxy coated MS ☐	✓
43.	<u>CONNECTION & DIMENSIONS:</u>	
44.	Instrument Process connection type : Flanged ☒ Threaded ☐	✓
45.	Threaded size :	x
46.	Flange size & rating :	*
47.	Cable entry: 1"ET ☐ ½ " NPT ☐ others ☐	*
48.	<u>WIRELESS TRANSMITTER</u>	x
49.	Transmitter update rate: Selectable between 4 sec to 60 sec	x

50.	Battery Voltage and Drain time:	x
51.	Battery life: Min. 2 yrs with 4 sec. update rate or better	x
52.	Antenna type : Integrated Omni directional Antenna ☐ Remote mount Omni directional Antenna ☐	x
53.	Signal Range: Minimum 200m or better without any repeater & with clear line of sight	x
54.	Wireless Frequency : 2.4GHz license free ISM Band	x
55.	Radio security : AES 128 bit encryption	x
56.	Wireless Protocol: ISA 100.11a (IEC 62734) / Wireless HART (IEC62591- 1)	x
57.	Transmitter Configuration : Via gateway over wireless network	x
58.	Device programming: Transmitter to work as input device, repeater and Access point	x
59.	Network: Note-10	x
60.	50.0 ACCESSORIES (REFER NOTE 3)	✓
61.	Name plate / metal tag :	✓
62.	Ph sensor :	✓
63.	RTD temperature sensor :	✓

64.	All installation hardware :	✓	68.	Electrical compliant with IEC / EN 61326-3-2	✓
65.	51.0 CODES & STANDARDS (Refer Note 2)	✓	69.	<u>TESTS</u>	✓
66.	Weather proof – IP / NEMA IS 13947 :1993	✓	70.	Performance	✓
67.	Explosion proof - IS 2148-1981/ BS EN 50014:1998 / BS EN 60079-0:2004/FM/CSA	✓	71.	Calibration	✓
			72.	Hydro test	✓

Notes :

- (*) - Bidder to furnish details; (□) - Required; (x) - Not required / Not applicable.
- The bidder shall indicate all applicable codes and standards.
- All accessories shall be supplied as applicable.
- Sampling system comprising of sampling pumps, rotameter, strainer, adjustment valve etc. shall be provided where the sample is to be taken from an open channel or from an unpressurised line.
- Sampling system comprising of pressure reducing valve, rotameter, strainer, adjustment valve etc. shall be provided where the sample is to be taken from a pressurised line.
- A mounting rack shall be provided for mounting of strainer, rotameter, adjustment valve, sensor holder, flow through assembly, transmitter, holders for ph & temperature sensor etc.
- Bidder shall consider acidification unit assembly for fluid ph correction beyond allowed/ recommended sample pH value.
- Self diagnostic features shall include alarm for, calibration fault and measuring parameter low / high.
- Field bus based transmitter shall meet the following requirement :
 - All instruments must satisfy the requirement of field bus registration laboratory with applicable check marks like foundation field bus, profibus PA or as specified.

- b) All instruments shall have two (2) analog input blocks as minimum. Also if specified the transmitter shall have PID controller block.
- c) All instruments must be interoperable and shall have valid interoperability test clearance like ITK 6.1.1 or latest for foundation field bus or equivalent for PA as applicable.
- d) The field bus instrument shall support peer to peer communication.
- e) Field bus instrument offered shall not be polarity sensitive
10. All the transmitters supplied for wireless network shall come with common batteries so that spare maintenance could be easier (These batteries should be compatible for all the models of Pressure, Temperature, Adaptor supplied in this network) Transmitter shall be supplied with battery removed during shipping.
11. Wireless connectivity and all devices shall be pre configured / field configurable with Mesh / Star / combination of both topologies with all devices configured as Transmitter, repeater based on application requirement.
12. Adapter is required for converting an existing wired transmitter to wireless complying with IEEE 802.154.
13. Self diagnostics features such as configuration error, battery alarm, and wireless communication alarm and over-range error for process variables

8. Magnetic Float Type Level Switch

1.	52.0 GENERAL	
2.	Manufacturer :	*
3.	Model No:	*
4.	Tag No:	*
5.	53.0 Quantity:	*
6.	Area classification: Zone 0 ☐ 1 ☐ 2 ☐ ; Group IIA ☐ IIB ☐ IIC ☐ ; TEMP. CLASS T1 ☐ T2 ☐ T3 ☐ T4 ☐ T5 ☐ T6 ☐	x
7.	Weather protection class: IP 65 ☒ IP 66 ☐	✓
8.	Ex-Proof : Exd ☐	x

9.	Enclosure material: Di Cast Al ☐ Epoxy coated aluminium ☒ Polyurethane Covered Aluminium ☐	✓
10.	54.0 PROCESS DATA:	*
11.	55.0 FEATURES:	✓
12.	Type: Magnetic float with guide tube ☒ Tilt type ☐	✓
13.	Accuracy: ± 2 mm	✓

14.	Mounting: Direct ☒ External chamber ☐	✓
15.	Switch Diff: Fixed ☐ Adjustable ☒	✓
16.	<u>GUIDED FLOAT TYPE</u>	
17.	Switch type: glass encapsulated hermetically sealed reed switch ☒	✓
18.	No. of floats with stopper: single ☐ multiple ☐	*
19.	C-C distance for external chamber mounted switches: mm	*
20.	<u>TILT TYPE</u>	x
21.	Switch type: Microswitch encapsulated in float	x
22.	No. of floats: single ☐ multiple ☐ Refer followup sheet	x
23.	<u>56.0 MATERIAL OF CONSTRUCTION:</u>	
24.	External chamber with drain/ vent arrangement: CS A105 ☐ SS 316 ☐ PP ☐	x
25.	Float: 316 SS ☐ PP ☒ Others ☐	✓
26.	Guide tube: 316 SS ☐ PP ☒	✓
27.	Bolts & nuts : ASTM A 193 Gr.B7 / A194 Gr.2H	✓

28.	Gaskets : PTFE ☒ OTHERS ☐	✓
29.	Wetted parts: SS 316 ☐ PP ☒ OTHERS ☐	✓
30.	Flange: SS 316 ☐ PP ☒	✓
31.	Cable for tilt switch:	x
32.	Counter weight for tilt type switch:	x
33.	<u>57.0 CONNECTION & DIMENSIONS</u>	
34.	External chamber connection type: Upper side - lower side ☐ 58.0 Upper side - lower bottom ☐	x
35.	External chamber process connection size: ½" ☐ 1" ☐ others ☐ Type : NPT ☐ flange ☐ SW ☐	x
36.	Drain arrangement for external chamber Valve ☐ Plug ☐	x
37.	Vent plug :	x
38.	Instrument Process connection (Refer note 3.0): 4" ANSI class 150 RF flanged ☐ 3" ANSI class 150 RF flanged ☐	*
39.	Cable entry: 1"ET ☐ ½ " NPT ☐ others ☐	*

40.	<u>SWITCH DETAILS:</u>	✓
41.	Controller : Required for converting reed switch to POT Free Relay Output	✓
42.	Alarms : HI ☐ LO ☐	*
43.	59.0 No. and type of contacts: 1 No SPDT ☐ 1 No DPDT ☒	✓
44.	60.0 Contact rating: 5A@ 230 V AC ☐ 2A@24VDC ☐	✓
45.	61.0 <u>ACCESSORIES:</u>	
46.	62.0 Still well for direct mounting	✓
47.	63.0 Counter weight to keep tilt type switch cable and float in position	x
48.	Name plate : Removable – SS	✓
49.	Metal tag – SS	✓
50.	<u>CODES AND STANDARDS</u> (REFER NOTE 2)	
51.	Weather proof – IP / NEMA IS 13947 :1993	✓
52.	Explosion proof - IS 2148-1981/ BS EN 50014:1998 / BS EN 60079-0:2004	x
53.	Electrical compliant with IEC / EN 61326-3-2	✓
54.	<u>TESTS</u>	
55.	<u>Calibration</u>	✓
56.	Material test certificate	✓
57.	Performance test	✓

Notes:

1. (*) - Bidder to furnish details; (✓) - Required; (x) - Not required / Not applicable.
2. The bidder shall indicate all applicable codes and standards.
3. Float size shall be suitable to process conditions and tank height. Accordingly, instrument flange size shall be selected.
4. Terminal size shall be suitable to accept 1.0 mm² cable for signal and 2.5 mm² cable for power supply.
5. Bidder to specify requirement of any special tools & tackles required at site during erection, commissioning and maintenance of the instrument.
6. Bidder to include list of spares and consumable required during erection & commissioning till handing over of the instrument.
7. Abbreviation used under switch action are as follows
 - a. OFL- opens on falling level
 - b. CFL- closes on falling level
 - c. ORL- opens on rising level
 - d. CRL- closes on rising level

9. Junction Box

Sr.No.	Description	
	GENERAL	
1.	Manufacturer	
2.	Model No.	
	FEATURE	
3.	Mounting	Wall/ column
4.	No. of terminals	32 (2x16)

5.	Terminal type	Screwed
6.	Terminal size	Suitable for 2.5 sq. mm. wire
7.	Mounting plate	Required
8.	Cable entry	Bottom
9.	Gland plate	Removable
10.	Door	Single lockable door with gasket
11.	Lock & key	Required
12.	Sheet thickness	3 mm
13.	Painting	Inside: glossy white; Outside: RAL 7032
14.	Protection class	Weather proof to IP 65
	MATERIAL OF CONSTRUCTION	
15.	Enclosure	MS with epoxy painting
16.	Gasket	Neoprene
17.	Cable entry sealing	Fire proof compound
18.	Name plate/ metal tag	Fixed SS304
	Installation hardware	Required

10. Interposing Relay (IPR)

Sr.No.	Description	
	GENERAL	
1.	Manufacturer	
2.	Model No.	
	FEATURE	
3.	Type	Electromagnetic
4.	Connections	Plug-in type
5.	Mounting	channel/ rail mounting in cabinet
6.	Coil rating	24V DC
7.	Change over contacts	2 sets
8.	Contacts rating	0.2A, 220V DC
9.	Freewheeling diode	Across relay coil
10.	Status indicator flag	self reset type (electronic)
	Installation hardware	Required

11. Instrumentation & Control Cables

		Description	Power Cables (for 24V DC)	Control cable	Signal cable	Triad Cable
	1.	Type		Screened, armoured	Twisted, screened, armoured	
GENERAL	2.	Voltage grade	1100 V	1100 V	500 V	
CONDUCTOR	3.	Material	Annealed Tinned Copper as per IEC 60288		Annealed Tinned Copper as per BSEN-50288-7	
	4.	Shape of conductor	Stranded circular – Class 2		Stranded circular – Class 2	
	5.	Size	Refer follow up sheet		Refer follow up sheet	
	6.	No. of strands	7 nos.		7 nos.	
PRIMARY INSULATION	7.	Material	XLPE as per IEC 60502-1		Extruded Polyethylene (PE) as per BS-EN 50290-2	
	8.	Thickness of insulation (Nominal)	As per IEC 60502-1	As per IEC 60502-1	As per BSEN-50288-7	
	9.	Colour code	Red, yellow, blue	Grey	White +ve, Black –ve (For each pair)	Brown, Black and blue
	10.	Twist	NA	NA	Min. 10 nos. twist / meter for each pair	

INDIVIDUAL PAIRS / TRIADS	11.	Identification		NA	NA		Numbers at not more than 250mm length			
INDIVIDUAL PAIR / TRIAD SCREENING	12.	Material		NA	NA		Al Mylar tape applied helically with metallic side down in contact with drain wire			
	13.	Tape thickness		NA	NA		mum 0.075 mm thick for single pair cables			
							mum 0.05 mm thick for multipair cables			
	14.	Overlap	Coverage	NA	NA		Min.25%	100%	Min. 25%	100%
	15.	Polyester tape		NA	NA		Polyester tape of 0.05 mm thick each. one tapes with min. 25% overlap & 100% coverage			
	16.	<u>Drain wire</u>								
	17.	Material		NA	NA		Annealed Tinned Copper			
	18.	Size		NA	NA		0.5mm ² , with 7 strands, each of 0.3 mm dia.			
OVERALL SCREENING	19.	Material			AL Mylar tape applied helically with metallic side down in contact with drain wire					
	20.	Tape thickness			mum 0.075 mm					
	21.	Overlap	Coverage	NA	Min.25%	100%	Min.25%	100%	Min. 25%	100%

	22.	<u>Drain wire</u>		
	23.	Material	NA	Annealed Tinned Copper
	24.	Size	NA	0.5mm ² , with 7 strands, each of 0.3 mm dia.

12. Programmable Logic Controller (PLC)

Sl. No.	Description			Bidder to state/confirm
1.0	GENERAL			
1.1	Project Name	:		
1.2	Customer Name	:		
1.3	Manufacturer	:	*	
1.4	Model no.	:	*	
1.5	Proven track record	:	Latest system and system configuration available / being marketed in the international market by the bidder / collaborator with 1 year of proven performance record. The offered hardware & software shall have a proven track record of one installation which is currently functional. The offered configuration with the offered models of the modules – controller, IO interface modules, Ethernet interface modules, serial link modules, IO modules, power supply modules, etc & the offered type of data highway & its type of network, type of IO bus & its type of network, type of OPC links, no. of remote IO links, maximum distance of remote link, etc, shall be in operation for minimum period of 1 year in a similar application.	✓

1.6	Criteria for proven track record	:	Same controller as per the proven performance record.	
1.7	System configuration	:		
1.8	List of users. Also specify about the manufacturing setup.		To be enclosed by Bidder Indicate the users where it is supplied for a similar application with similar configuration & indicate the no. of successful years of operation.	
1.9	Control room environment	:	24°C ± 1°C	
1.10	Total nos. of cabinets	:	*	
1.11	System power supply	:	Redundant from UPS - AC DB 240 V AC ☐	
1.12	Card replacement with power on for systems	:	Required, Hot-swapping.	
1.13	Configuration diagram	:	Bidder to enclose the configuration diagram for the system offered.	
1.14	System Expandability	:	Modular system design with capability and facility for modular expansion is required.	
1.15	PLC with open system architecture to enable integration of third party system	:	Required.	
1.16	Open Protocols to be supported by PLC system for third party interface	:	Required through a) Modbus TCP – IP b) Ethernet connectivity	

1.17	Spare nodes in the IO bus	:	20%	
1.18	Spare capacity for system memory and user memory	:	50% (After configuring the system and application software, considering the installed spares) The same shall be indicated in Bidder's offer by means of calculations and shall be demonstrated at site during Site Acceptance Tests.	
1.19	Surge withstand capability as per IEEE Standard	:	Required	
1.20	Special tools and tackles	:	Bidder to quote special tools and tackles required for installation, testing, commissioning & future maintenance.	

1.21	Posting of 1 hardware and 1 software engineer during erection, commissioning & final acceptance test	:	1. Bidder to indicate organisation chart at site 2. During warranty period, the maintenance call must be attended within 24 hours. The plan from the bidder must be submitted to support this requirement. 3. Subsequently bidder must separately quote for comprehensive AMC rate valid for one years. 4. Contractor's engineer shall be made available for assistance in operation, maintenance, tuning & training of Purchaser's personnel at Site after commissioning of PLC. Rates for the same shall be indicated in schedule of personnel. 5. Training of owner's engineer for both hardware & software development at site. Duration: _____ No. of engineers: _____	
2.0	CONTROLLER SUB-SYSTEM			
2.1	Microprocessor based	:	Yes	

2.2	Configurable multi loop controller	:	Required, PLC shall be capable of running multiple loops of different scan times with assigned priority.	
2.3	Scan time	:	All I/Os shall be scanned Interlocking I/Os: within 50 ms Sequential logic: within 100 ms PID control: within 250 ms Analog Monitoring: within 500 ms It shall be possible to allocate different scan times to different I/O points.	
2.4	Controller redundancy	:	Required	
2.5	Power supply dual redundancy (controller)	:	Required	
2.6	Power supply dual redundancy (I/O racks)	:	Required	
2.7	Status monitoring of power supply modules of CPU & I/O modules	:	Required for monitoring at the HMI	
2.8	<u>Processor</u>			
2.8.1	Model no.	:	*	
2.8.2	Processor and word length	:	32 bit ☐ 64 bit ☐	.
2.8.3	I/O redundancy	:	Required for critical IOs based on project specific requirement.	
2.8.4	Processor redundancy	:	Not Required	

2.8.5	Primary & Secondary indication on controllers	:	LED indication required.	
2.8.6	I/O capacity of each controller	:	*	
2.8.7	Logic changes possible through laptop/HMI	:	Yes, with necessary security	
2.8.8	Debugging/ simulation software	:	Should be preloaded in HMI as a system feature	
2.8.9	Self-diagnostics software required	:	In each processor	
2.8.10	Online configuration possibility	:	Required	
2.8.11	Logic changes in main processor	:	Required	
2.8.12	Simultaneous Downloading of programs into both the Processors (main & redundant) by one click.	:	Not Required.	
2.8.13	Online logic changes or Manual data entered (as set point or A/M selection, forcing the outputs to some value, etc.,) done in primary controller	:	Required	
2.8.14	Output status on loss of power	:	Outputs shall go to fail safe position which shall be user defined	
2.8.15	Sequence control functions	:	Required	
2.8.16	Control modes	:	Auto, Menu driven, Discrete	
2.8.17	User memory	:	*	
2.8.18	Memory type for configuration	:	*	

2.8.19	Battery type	:	1 year lifetime: Ni-Cd ☐ other proven options ☐	
2.8.20	Battery drain alarm/ indication	:	Required, on HMI	
2.8.21	Estimated CPU load with furnished configuration	:	CPU loading shall not exceed 50% under worst data loading condition considering used IOs, spare IO channels, spare IO modules, spare IO slots & specified scan time. The same shall be indicated in Bidder's offer by means of calculations and shall be demonstrated at site during Site Acceptance Tests.	
2.8.22	Synchronisation of real time clock	:	Not Required	
3.0	ALGORITHMS REQUIRED AS A MUM			
3.1				
A	Alarm check functions	:	Input/ output open check	
		:	High-high, high,	
		:	Low-low, low	
		:	Velocity & deviation	
		:	Hysteresis	
		:	Bypass	
		:	Output open	

B.	Output processing Function	:	High/low alarm	
		:	High/low limiter	
		:	Velocity limiter	
C.	Control algorithms	:	Proportional control	
		:	PI, PID, PD and adaptive gain	
		:	External feed back facility	
		:	Sample & hold PID, PID with batch switch	
		:	Ratio control	
		:	PID with dead band	
		:	Cascade control	
		:	On-off control	
		:	Feed forward control	
		:	Mathematical Functions	
		:	Logic Functions	
D.	Selector	:	Low	
		:	High	
		:	Mean value	
		:	Median	
		:	Over ride	
3.2	Galvanic isolation for input/output & power supply	:	Required	

3.3	Self diagnostic tests			
A.	Input diagnostics	:	Required	
B.	Configuration diagnostics	:	Required	
C.	Memory diagnostics	:	Required	
D.	System hardware check	:	Required	
E.	Output diagnostic	:	Required	
F.	External hardware check	:	Required	
G.	Power system Diagnostics	:	Required	
H.	Alarm indication in MMI when any self-diagnostic test fails	:	Required	
4.0	COMMUNICATION SUB- SYSTEM			
4.1	Architecture	:	Bus structure required	
4.2	Type of protocol for communication between MMI & controller	:	Ethernet, IEEE 802.3 u	
4.3	Speed between HMI & controller	:	* Min. 100 Mbps	
4.4	Redundant communication between HMI & controllers	:	Required	
4.5	Method of communication Ring / Mesh / Star Type	:	*	

4.6	Communication modules for controllers for communicating with I/O bus	:	Required	
4.7	Communication modules in I/O or Remote I/O panels for communicating with controllers	:	Not Required	
4.8	Type & speed of communication between I/Os and controller Method of communication Ring / Mesh / Star Type	:	* Min. 10 Mbps. In case of lower speed. Bidder will justify how the functional requirement will be met.	
4.9	Type of I/O bus communication	:	Ethernet, IEEE 802.3 u ☒ Modbus TCP/ IP ☒ OPC ☒ Modbus RTU ☒	
4.10	Maximum no. of nodes (Controller/I/O modules) on the system bus	:	*	
4.11	No. of I/O modules per node	:	*	
4.12	Maximum length of the system cable I/O bus	:	*	
4.13	Bus loading allowed	:	≤ 50% under worst data loading condition. The same shall be indicated in Bidder's offer by means of calculations and shall be demonstrated at site during Site Acceptance Tests.	
4.14	Levels of protection for message transmission			

A	Hand shaking	:	Required	
B	Errors by external noise	:	Required	
C	Checks on data acquired	:	Required	
D	Message retransmission Or other schemes for Orderly recovery if a Message is lost	:	Required	
5.0	Human MACHINE INTERFACE SUB-SYSTEM (HMI)		Centralised SCADA interface purpose	
5.1	Quantity	:		
5.2	Make/model	:		
5.3	Type	:	Refer Clause No. 18: 'Minimum Specifications for Engineering & Operator Workstations'	
5.4	<u>Features of Data Acquisition & Control System Software</u>		Centralised SCADA software	
5.4.1	Trending function	:		
A	Real time	:	Required	
	Trend assign parameters as min.	:	PV, MV, SEV etc.	
	No. Of parameters	:	*	
	Sampling time	:	*	

	Time base	:	*	
B	Historical trending			
	No. of parameters	:	*	
	Sampling time	:	*	
	Time base	:	*	
C	No. of points per trend page	:	*	
	Trend points for sampling time of 1 sec to 10 sec and full scale time base of 4,6,16,32 minutes/ hours/ days for tuning the process loops	:	Required	
5.4.2	Logging functions			
A.	Log formats	:	User definable	
B.	Event logging	:	Required	
C.	Hourly logs	:	Required	
D.	Shift logs	:	Required	
E.	Daily logs	:	Required	
F.	Weekly logs	:	Required	
G.	Logging frequency	:	* (User selectable)	
H.	Operator actions	:	To be logged	
5.4.3	Alarm display function			
A.	Last alarm always to Appear on top of screen	:	Regardless which page is being seen	

B.	No. Of alarms / page	:	*	
C	No .of Alarms Stored	:	*	
D.	Differentiation between Process & system alarms	:	Required	
E.	Alarm return to normal	:	Required. To appear in a separate line with time.	
F.	Group display function	:	Required	
G.	Total no. of groups	:	*	
H.	No. of loops per group	:	*	
5.4.4	No. of windows opened at a time	:	*	
5.4.5	Information display group	:	8 faceplates per window with following details	
A	Input	:	Required	
B	Output	:	Required	
C	Set point	:	Required	
D	Tag nos.	:	Required	
E	Set point status	:	Required	
F	Mode status	:	Required	
G	Service description	:	Required	
5.4.6	Print message history required	:	Yes	
5.4.7	Alarm handling while continuous alarm condition	:	Required	

5.4.8	Faceplate details should be user selectable	:	Required	
5.4.9	Faceplate indication colors selection	:	Easy, Menudriven required	
5.4.10	Tag security for individual tags	:	Required	
5.4.11	MMI database should be selectable	:	Possible by assigning MMI name/PC no.	
5.4.12	Control drawing & logics for engineering & use	:	High level language (like Ladder/Function blocks / Other as per Manufacturer Standard)	
5.4.13	Change in Engg. Unit of any tag is made should get reflected in the graphics also	:	Required	
5.4.14	Change of operation mode : auto, manual, cascade	:	Required	
5.4.15	Alarm priorities and levels	:	Min. 5 levels	
5.4.16	Operation mark on the tag : Faceplates & Graph	:	Required – e.g. - service, repair, calibration, maintenance, no operation etc.	
5.4.17	Safe operation range indicators on tag's faceplate	:	Required for safe operating range : low & high	
5.4.18	Alarm & trip mark indicators on tag's faceplate	:	Required for : low-low, low, high & high-high level	
5.4.19	Clamp input facility	:	Required to be clamped if goes beyond certain range/value	

5.4.20	Repeat alarm after preset time for critical poll	:	Required, even if it is acknowledge by operator but still in alarm stage	
5.4.21	Pass, fail, stuckup status for every sequence	:	Required, to know where the process sequence has stuckup	
5.4.22	Scan time setting for individual sequence table	:	Required	
5.4.23	Timers counting capacity	:	Upto 9999 seconds and/or 9999 minutes	
5.4.24	Generate flags from timer status	:	Required from : on, stop, deviation, pause	
5.4.25	Pause facility in the timer	:	Required	
5.4.26	Counter counting capacity	:	Upto 9999 (0 to 9999 or 9999 to 0)	
5.4.27	Functional blocks	:	Readymade library for ease of engineering	
5.4.28	Faceplate to appear on trend display on call	:	Required	
5.4.29	Scrolling facility in the stored trend	:	Required	
5.4.30	Trend pause, compress/ expand 'x' & y axis	:	Required	

5.4.31	History storage	:	Required for all process parameters, all process/ system alarms, operator action, upsets, changes etc. 6 GB storage capacity for history storage Sampling rates shall be user selectable	
5.4.32	Search feature on alarm, history, operator action etc.	:	Required	
5.4.33	Connected with	:	Engineering Station ☐ Operating Station Network ☐ Other ☐	
5.4.34	HMI Compatible with	:	OPC/ UA	
6.0	ETHERNET SWITCH (LAYER-2)			
6.1	Bidder shall submit Ethernet switch – Layer – 2 & Layer – 3 level configuration for Purchaser's approval. Grouping of different controllers, HMIs under Ethernet switch shall be subjected to Purchaser's approval during detailed engineering.	:	*	
6.2	Type	:	Industrial Grade, Manageable, Layer-2 Fast Ethernet switches, with at-least 2 Fibre Optic Port	
6.3	Make	:	As per Approve make list	

6.4	Model No.	:	*	
6.5	Number of Ports	:	8 ports (10/100 Mbps) full duplex electrical ports and 2 uplink ports (FO) (1Gbps). Refer PLC configuration drg.	
6.6	Auto sensing & Auto-negotiating ports	:	Required	
6.7	SNMP management features	:	Required	
6.8	Power	:	230 V AC, UPS required, dual intake (Redundant)	
6.9	Diagnostics	:	LEDs for Power, duplex mode indication, flow control activation, collision indication (when working in half duplex), CRC indication	
6.10	Security	:	Port Security	
6.11	Quality of Services (QOS)	:	Required	
6.12	Spanning tree protocol	:	Required	
6.13	1 No. Licensed copy of management software	:	Required of the same make as the Ethernet switches	
6.14	Type of communication on LAN	:	Ethernet, IEEE 802.3 u	
6.15	Communication Protocol for LAN	:	TCP/IP	
6.16	Virtual LAN capability	:	Required	
6.17	Operating Temperature	:	Up to +60° C ambient	
6.18	Quantity	:	Xx Nos. 1 No. to be provided separately.	

7.0	FIBRE OPTIC CONVERTERS		INTEGRAL TO NETWORK SWITCH WITH LIU & FO PATCH CORDS	
8.0	INPUT/OUTPUT SYSTEM			
8.1	I / O series (model no)	:	Bidder shall offer IO module series that are latest & best suitable for the offered controller. Subjected to Purchaser's approval.	
8.2	Signal isolation for all I/Os	:	Optical or galvanic	
8.3	Individual fuse for each I/O point	:	Required, Fused Terminals shall be provided.	
8.4	Module failure indication in module and PLC	:	Required	
8.5	Indication and alarm in PLC for module failure	:	Required	
8.6	Channel – to –channel isolation	:	Required for each input & output modules	
8.7	Chanel to back plane isolation	:	Required	
8.8	Fault status of each channel of each input/output module	:	Required for monitoring on MMI	
8.8.1	Intrinsic safe barrier for instruments located in Hazardous area	:	Required	
8.8.2	Type of isolation	:	Optical/Galvanic	
8.8.3	Support HART Protocol to carry out all diagnosis & calibration	:	Required	
8.9	<u>Analog output module</u>			

8.9.1	Model No.	:	* (Same series as that of Controller)	
8.9.2	No. of points per module	:	6 / 8	
8.9.3	Type of outputs	:	4-20 mA	
8.9.4	Resolution	:	12 bit including sign	
8.9.5	Accuracy	:	± 0.1% of full scale	
8.9.6	Intrinsic safe barrier for instruments located in Hazardous area	:	Required	
8.9.7	Type of isolation	:	Optical/Galvanic	
8.9.8	Support HART Protocol to carry out all diagnosis & calibration	:	Required	
8.10	<u>Digital input module</u>			
8.10.1	Model No.	:	* (Same series as that of Controller)	
8.10.2	No. of inputs / module	:	16 / 32	
8.10.3	Type of input	:	Potential free contacts	
8.10.4	Type of isolation	:	Optical	
8.10.5	LED status indication for each input	:	Required	
8.10.6	Interrogation voltage	:	External 24V DC	
8.10.7	Filtering at input stage	:	Required	
8.11	<u>Digital output module</u>			
8.11.1	Model No.	:	* (Same series as that of Controller)	
8.11.2	No. of outputs per module	:	16	

8.11.3	Type of outputs	:	Relay outputs (TTL outputs not acceptable)	
8.11.4	Output contact rating of interposing relays	:	2A, 220 V DC for Breaker operated drives and 5A, 230 V AC for rest application (2CO for each relay)	
8.11.5	Discrete relays/relay boards	:	Relays mounted on relay boards to be provided (maximum of 8 in a board).	
8.11.6	LED status indication for each output	:	Required.	
8.11.7	Output Status	:	Outputs shall change to fail-safe position in case processor failure or module failure.	
8.11.8	Power Supply	:	*	
8.11.9	Interface Module	:	*	
8.12	<u>I/O Summary</u>			
8.12.1	Analog inputs (4-20 mA)	:	Refer Appendix –1 for I/O Count summary of each facility.	
8.12.2	Analog outputs (4-20 mA)	:		
8.12.3	Digital inputs (24V DC)	:		
8.12.4	Digital outputs (potential free)	:		
9.0	APPLICATION PROGRAMME	:	To be provided in R/W DVDs (2 Nos.) for each facility.	
10.0	PROGRAMMING UNIT (preferably LAPTOP)			
10.1	Make	:	Compaq/Toshiba/HP/IBM (Lenovo)/Dell	

10.2	Quantity	:	x no.	
10.3	CPU	:	Core i7 or better	
10.4	CPU speed	:	1.5 G Hz or higher.	
10.5	DDR RAM	:	4 GB or better as per availability in market	
10.6	Cache memory	:	minimum 6 MB	
10.7	Hard disk	:	500 GB	
10.8	Combo drive	:	DVD/CDRW Combo drive	
10.9	VDU	:	14 inch colour, LED display with 1366 x 768 or better resolution.	
10.10	Integrated	:	10/100 Mbps Ethernet LAN interface card IEEE 802.3 u, 802.11 b wireless Ethernet.	
10.11	Additional Communication ports	:	minimum one parallel, one serial (RS 232) and two USB ports.	
10.12	Mouse	:	Optical mouse	
10.13	Power supply	:	Universal AC adapter: 100 to 240 V AC (50 Hz) input; rechargeable lithium-ion battery with up to 4 hour run time, upto 7 hour total run time with primary and secondary batteries, fast battery recharge, low-battery warning	
10.14	External speakers	:	2 Nos. required. The Laptop shall be provided with necessary sound cards & drivers.	

10.15	Any other features	:	All standard features available on a laptop	
10.16	imum accessories to be provided			
A	Carry case	:	Required.	
B	Battery adapter	:	Required.	
C	Power chord	:	Required.	
D	LAN cable with connectors	:	Required.	
E	All cables & accessories required for connecting to PLCs/MMIs/ Ethernet switches	:	Required.	
13.0	Spares			
13.1	Input and output modules wired up to marshalling panels	:	___% of used I/Os of each type	X
13.2	Wired slots for mounting the spare modules	:	_20_ % of used slots	X
13.3	Interposing relays wired in cabinet for all wired spare digital outputs	:	Required	
13.4	Terminals mounted in each panel	:	_20_% of used terminals	
13.5	MCBs mounted in each panel	:	___% of used MCBs	X
13.6	Spare space in the cabinets to install additional relays in future	:	_20_% of used relays	
13.7	Unused node addresses in communication network	:	___%	
14.	Spares to be kept in store			

1.1	Modules	:	_20_ % of used modules of each type or 1 no. of each type whichever is higher	
1.2	Interposing relays	:	_25_ % of used relays	
1.3	Terminals of each type	:	_20_ % of used terminals	
1.4	Safety Barriers, Signal Converters, Trip Amplifiers, Relays etc.	:	____ % of used	X
1.5	Operating workstation along with monitor, mouse, keyboard & 1 TB portable hard disk	:	____ nos.	X
1.6	Fuses of each rating	:	____ % of used	
1.7	Bulk power supply unit of each rating	:	____ nos. of each rating	
1.8	Communication system components such as hubs, switches, router	:	____ % of used	X
1.9	Disks, disk drives, switches, lamps, push buttons, etc	:	____ % of used	X
1.10	Consumable including printer cartridges, Paper or any other consumable items	:	For ____ months / years after handing over.	X
2.	MCBs	:	____ % of used MCBs	X
2.1	Separate MCBs for isolating each device	:	Required.	
2.2	Separate redundant SMPS for Controller, I/O Modules & SOV	:	Required.	

2.3	Shall supply 230 V AC Non-UPS power supply to fan, panel heater, sockets and illumination lamp in all panels	:	Required.	
16.	FACTORY ACCEPTANCE TEST			
16.1	FAT procedure shall be submitted for Purchaser's approval before commencement of FAT	:	Required	
16.2	A 100% integrated system simulation test shall be carried out in the shop to test all the hardware and software including all communication links to third party systems	:	Required.	
16.3	PURCHASER /CONSULTANT's representative shall participate in the FAT at works, prior to despatch	:	Required.	
16.4	FAT shall be carried out as per final approved drawings / documents	:	Required.	
16.5	Various tests to be covered in FAT shall be as per FAT Data sheet (TCE. M4-109-FAT-111) enclosed	:	Required.	
16.6	VENDOR should have performed all standard basic functional tests prior to start of FAT	:	Required.	
16.7	Throughout the FAT supply all necessary test equipment and consumable	:	Required.	

16.8	VENDOR shall be responsible for making all connections between system components, peripherals and test equipment, including foreign device interfaces	:	Required.	
16.9	Supply software and hardware technical support of sufficient standard to ensure mal delays during the interface-testing program	:	Required.	
16.10	Calibration certificates traceable to National/ international Standards for test instruments used during inspection	:	Required.	
17.	SITE ACCEPTANCE TEST (SAT)			
17.1	Close loop checking, Open Loop and Interlock checking	:		
17.2	System loading (CPU, bus & memory) after commissioning	:		
17.3	Control Loop update time	:		
17.4	Screen update time	:		
17.5	VENDOR shall submit a SAT Procedure for PURCHASER/ Consultant's review. The final SAT shall be carried out on the basis of this approved document	:		
18.	DOCUMENTS			

18.1.1	Following documents to be furnished by VENDOR along with the bids			
18.2	System architecture/Configuration drawing indicating redundancy at all levels and all hardware components	:		
18.3	System-wise Bill of Material (BOM).	:		
18.4	Catalogues of all products listed in the BOM	:		
18.5	System-wise Power distribution & power consumption	:		
18.6	Number and size of each panel offered	:		
18.7	List of Deviations	:		
18.8	Delivery Schedule	:		
18.9	List of documents required by the VENDOR	:		
18.10	List of calibration equipment available with the VENDOR along with valid calibration certificates	:		
18.11	Data duly filled in the data sheets enclosed with entire data sheet stamped & signed	:		
18.12	Mandatory spare parts list	:		
18.13	Recommended spare part list	:		

18.14	Control Room Layout	:		
18.15	Following drawings / documents to be furnished by VENDOR after award of contract			
18.16	Bar chart for the design, manufacturing, erection, commissioning, trial operation and performance testing of the system offered.	:		
18.17	Overall System Architecture	:		
18.18	System Functional Write-up	:		
18.19	Unpriced purchase order copy for various bought out /sub contracted equipment / services	:		
18.20	Following drawings for PLC System Cabinets, I/O racks, Marshalling cabinets, Control desks & Power distribution boards	:		
a)	Front facia layout showing all instruments with cut-outs, bezel dimensions, construction details, foundation details and interior G.A. drawings showing interior layout of various modules on racks			
b)	Internal wiring diagrams indicating termination details of each component.			

c)	Bill of Material (B.O.M.) indicating tag no., quantity, service & model no. of the various instruments/items.			
18.21	Power Supply Distribution Scheme for the entire I&C system indicating quantity of feeders and type & rating of each feeder in each PDB			
19.	Following drawings / documents for PLC system			
a)	Configuration drawing			
b)	Make Model No., Catalogues, Data sheets for CPU modules, I/O modules, Communication modules and all other modules of the PLC system and engineering stations			
c)	I/O list indicating grouping of various signals in each module (I/O assignment).			
d)	Nest Loading drawings/documents			
e)	Sequence & logic diagrams and control schemes			
f)	Operating manual for PLC system			
g)	Hardware and software manuals			
h)	Configuration data			
i)	Trouble shooting manual			

j)	Network Topology			
k)	Arrangement of cabinets with dimensions			
l)	Alarm wiring			
m)	Material List			
n)	Software Installation List			
o)	Fuse List			
p)	Printer settings			
q)	Description of software protocols			
r)	Settings of DIP-Switches			
s)	Cable List			
19.1	Following drawings for Operator Stations:			
a)	Data sheets of hardware including communication protocol details			
b)	Listing of alarm messages.			
c)	Catalogues			
d)	Screen Layout			
e)	Log sheets & report sheets			

f)	Control Schemes for Operator Stations			
g)	Details of Software Package in the Operator Stations indicating various functions & facilities available			
h)	Wiring Diagram			
19.2	Data sheets & details of software packages for Engineering Station and Asset Management System / Alarm management system.			
19.3	Heat load and Power consumption for A.C. & D.C. loads			
19.4	Data sheet and load calculations for DC power supply units			
19.5	Data sheets for Ethernet switches			
19.6	QAPs for all items like panels, control desks, junction boxes, cables			
19.7	Earthing diagrams for cabinet & entire system			
19.8	Loop diagrams, Cable Schedules and Interconnection cable schedules.			
19.9	Standard FAT & SAT for the specified systems			

19.10	Detailed instruction manual for the entire PLC (operation & maintenance)			
19.11	As Built' drawings			
19.12	Instruction manual for installation and start-up.			
19.13	System operation and maintenance manual			
19.14	Protocol listing (hard and soft) copies			
19.15	Copy of licenses for various software to be supplied			
19.16	Guarantee certificate			
20	The product warranty must include following points:			
a)	Provide ____ years warranty from the date of acceptance of the system after installation, integration, commissioning			
b)	Include comprehensive preventive and break down maintenance including all types of spares and software. The software up-gradation is to be free of cost during this period			
c)	The supplier engineer shall make quarterly visit to check the healthiness of the system and shall submit the reports of the same to PURCHASER during his quarterly visit.			
d)	Supplier has to provide on-site various operation and maintenance support like programming of various features, changing class of services, reconfiguration, including modifications, creations, up-dating and expansion			

e)	Vendor to quote for Comprehensive Annual Maintenance Contract rate valid for 1 years after the warranty period	

13.0 STRUCTURAL DESIGN CONSIDERATION FOR STP

- (a) Design criteria of RCC structural units shall conform to the Design requirements of latest version of IS:456
- (b) The bidder shall ensure design drawings and construction is in conformity with the latest applicable Indian Standards and sound engineering practice.
- (c) Soil Condition, Ground Water Table and Bearing Capacity:

The Soil investigation report for the location is available and extract of the same is attached as part of tender document for designing the foundation system. The bidder may, if required, get himself satisfied with such investigation done at his end and nothing shall be paid on this account.

Bidder shall consider SBC as follows for designing the foundation system.

- 1. Raft Foundation shall be given at a depth of 6-7m with an SBC of 400kN/m² from NGL.**

The contractors shall submit the gross bearing pressure and other related documents for the structure, obtained after structural analysis, so that the SBC and the settlement of the soil at the proposed location shall be verified by Employer/PMC.

- (d) Foundations:

- (i) The foundation shall be designed as per relevant BIS codes.

- (e) **Design Loads:**

Buildings and structures for this project will be designed for the following loads.

- (i) Dead Load (DL)

The dead load is calculated on the basis of unit weight of materials given in code IS: 875 (Part 1). The dead load considered in the structural design will consist of the full weight of all known fixed structural elements. The weight of fixed service equipment and the weight of all process equipment including all fixtures (conduit, cable tray, ductwork, etc. permanently attached to the structure) and attached piping will be considered in dead load.

S. No.	Material	Density(kN/m ³)
1	Reinforced Concrete	25.0
2	Plain cement concrete	23.0
3	Cement Plaster	20.4
5	Structural steel	78.5
6	Water	9.81

S. No.	Material	Density(kN/m ³)
7	Autoclaved Aerated Concrete (AAC) blocks	7.0

(ii) Imposed Load (LL)

The imposed loads to be considered in the design of buildings shall be the greatest loads that probably will be produced by the intended use or occupancy. The imposed loads shall be considered as per IS: 875 (Part-2)

(iii) Wind Load (WL)

The wind pressure shall be calculated on the basis of data specified in IS 875 (Part 3)

(iv) Seismic Load (SL)

The earthquake forces shall be considered in accordance with IS: 1893 (Part-1) with following parameters:

(i) Importance factor : 1.0

(ii) Damping: : 5%

(iii) Seismic Zone: II As per IS 1893 (Part 1)

(v) Surcharge Load

Surcharge load to be considered for design of all underground structures to take in to account the construction load and vehicular traffic in the vicinity of structure.

(vi) Earth Pressure

Pressure for walls of basement/ tanks etc. will be calculated using coefficient of earth pressure. Unit weight of the soil and other soil parameters shall be considered as in below table. Seismic considerations of earth pressure calculations will be as per code IS: 1893-Part 3.

Bulk density of soil	18 kN/m ³
Dry density	16 kN/m ³
Porosity (%)	0.37
Void ratio (%)	0.6
Specific gravity	2.61
Cohesion C	0.25kg/cm ²
Angle of friction	26

(vii) Hydrostatic Pressure

The ground water pressure will be applied on the substructure as per geotechnical report in addition to the earth pressure.

(f) **Permissible Stresses**

- Whenever seismic forces are considered along with other normal design forces, the permissible stresses in material will be governed by the respective codes as per which the structure/equipment is being designed. In the absence of such code/standard, provisions of IS: 1893 will be used.
- Permissible increase in allowable bearing pressure of soil and pile Capacity provisions of IS: 1893 will be used.
- Earthquake will not be considered to act simultaneously with wind

(g) **Load combinations**

The load combinations considered shall be as per IS: 456 and IS: 1893 (Part-I).

(h) **Analysis Methods**

Three-dimensional computer analysis of the structure shall be performed incorporating various forces. seismic analysis Provisions of IS: 1893 (Part-I). The structural analysis and design shall be carried out using validated software(s).

(i) **Permissible Deflection**

The permissible vertical deflection for RCC members will be as per clause 23.2 of IS 456.

(j) **Structural Design**

- (i) All structural elements shall be designed according to the Limit state method as specified in IS 456:2000.
- (ii) Environmental exposure condition will be considered as MODERATE as per clause 8.2.2, Table-3 of IS 456.
- (iii) The Minimum grade of reinforced cement concrete will be M25 conforming to IS 456. For the storage of liquid, the minimum grade of concrete used will be M30 conforming to IS 3370.
- (iv) Concrete of minimum 75 mm thickness of lean concrete mix of grade M7.5 (by weight, using 40mm and downsize grade crushed stone aggregate) will be provided under all RCC foundations.
- (i) High Strength Deformed Reinforcement Steel bars of grade Fe 500, conforming to IS: 1786 will be used.
- (ii) All reinforcement will be detailed in accordance with IS 456, SP 34, IS 13920 for Plain and Reinforced Concrete structures.
- (iii) Minimum member sizes to meet the 2-hr fire rating will be adopted as per IS 456
- (iv) The nominal cover to the reinforcement will be based on the exposure condition as well as fire protection consideration as per IS 456
- (v) Durability of Steel structures will be ensured by painting in accordance with IS 1477 (Parts 1 and 2).
- (vi) For design of ties, key elements and joints etc. reference may be made to IS 15916

- (vii) The water retaining structures shall be designed by using working stress method. For this, relevant provision of IS: 3370 (Part-I to Part-IV) shall be followed.

(k) **Codes, Standards and Specifications**

The design will comply with the latest editions and revisions of the codes, specifications and standards listed below as noted, supplemented or modified herein:

S No.	Code Title	Code No.	Year
	Design		
1	National Building Code of India	NBC	2016
2	Code of practice for plain & reinforced concrete	IS 456	2000 (Reaffirmed 2021)
3	Code of practice for general construction in steel	IS 800	2007 (Reaffirmed 2017)
4	Code of practice for design loads (other than earthquake) for buildings and structures		
	Part 1, 2, 4, 5	IS 875	1987 (Reaffirmed 2018)
	Part 3		2015 (Reaffirmed 2020)
5	Criteria for earthquake resistant design of structures		
	Part1 - General Provisions and Buildings	IS 1893	2016 (Reaffirmed 2021)
	Part 2 – Liquid Retaining tanks		2014 (Reaffirmed 2019)
6	Code of practice for design and construction of foundations in soils: general requirements.	IS 1904	2021
7	Code of practice for concrete structures for the storage of liquids	IS 3370	2009 (Reaffirmed 2019)
8	Earthquake resistant design and construction of buildings - code of practice	IS 4326	2013 (Reaffirmed 2018)
9	Recommendations for detailing of reinforcement in reinforced concrete works	IS 5525	1969 (Reaffirmed 2018)

S No.	Code Title	Code No.	Year
10	Code of practice for Calculation of settlement of foundations - Part 1 - Shallow Foundations Subjected to Symmetrical Static Vertical Loads	IS 8009	1976 (Reaffirmed 2018)
	Materials		
12	Hot rolled medium and high tensile structural steel– Specification.	IS 2062	2011 (Reaffirmed 2021)
13	High strength deformed steel bars and wires for concrete reinforcement	IS 1786	2008 (Reaffirmed 2018)

(l) Software used for Analysis & Design

The structural analysis and design shall be carried out using validated software(s).

(m) Approval for Design and Drawings

1. Contractor shall prepare and submit DBR for STP design and get it approved by Employer/PC before proceeding with structural design.
2. Structural design and drawings for STP :

The contractor should design STP & prepare good for construction structure concrete and reinforcement drawing and get it approved by PMC/Employer. Contractor to submit design report for STP design consists of load calculations, foundation design calculations, analysis models such as ETABS/STAAD/SAFE, structural layout drawings, reinforcement drawings etc. to PMC/Employer and get the same approved by PMC/Employer. Upon approval contractor to get the design and drawings proof checked from reputed institutions like IIT/Anna University before proceeding with execution of work.

TECHNICAL SPECIFICATIONS FOR SOLID WASTE MANAGEMENT SYSTEM

CONTENTS

1.0	SOLID WASTE MANAGEMENT SYSTEM (SWMS).....	3
2.0	PROCESS DESCRIPTION.....	4
3.0	TECHNICAL SPECIFICATION FOR COMPOSTING SYSTEM (DATA SHEET).....	11
4.0	OTHER GENERAL INSTRUCTIONS	13

1.0 SOLID WASTE MANAGEMENT SYSTEM (SWMS)

1.1 INTRODUCTION

Municipal Solid Waste Management (MSWM) is one of the most problematic and neglected aspect of Indian Cities. Improper management of municipal solid waste (MSW) causes hazards to inhabitants. Also, high population growth and industrialization put strain on the basic infrastructural and municipal services.

Solid Waste Management is a part of public health and sanitation. Management of solid waste reduces or eliminates adverse impacts on the environment and human health and supports economic development and improved quality of life.

Human habitation and activities generate large quantities of solid waste. Solid waste is defined as 'non-soluble, unwanted/discarded solid materials, generated from combined residential, and floating population in a given area, including sewage sludge, municipal garbage, agricultural refuse, construction, and demolition wastes, etc.

Solid Waste Management is one among the basic essential services to be provided for the TIDEL IT Park Project at Madurai. The organic waste generated from the IT Park building is estimated to be around 450 kg/day for Phase 1.

The project proponent is proposed to install Solid Waste Management system of capacity 1000 kg/day for IT Park building. The current organic waste management system in Phase 1 requires a wet waste handling capacity of 0.45 tons. However, due to spatial limitations and to ensure future scalability for Phase 2, we propose the installation of organic waste management system unit with an increased capacity of 1.0 ton. The processing unit will process the entire wet garbage and convert the same into rich organic manure / compost. The waste consisting of vegetable peelings, fish wastes, rotten fruits, cooked food having rice, vegetables, chicken meat, sweets, biscuits, eggs, fruits, garden wastes, etc.

1.2 SCOPE OF WORK

Following shall be the scope of work for the successful bidder:

- 1) The entire garbage to be collected and transport from all floors to the waste treatment facility.
- 2) Design, construct, operate and maintain Solid Waste Treatment Facility of capacity 1000 Kg/day using Mechanized composing (In-vessel composting) for Biodegradable waste in accordance with provisions and in conforms to the construction requirements and O&M requirements. The system to be designed as per the Municipal Solid Waste (Management and Handling) Rules 2000.
- 3) Setting up Organic Waste Converter system of 1000 kg/day capacity for TIDEL IT Park.
- 4) Complete solution shall be provided by the vendor based on the concept of Integrated Solid Waste Management principles highlighted in Solid Waste Management (MSW) Rule, 2016 manual, starting from segregation to conversion to Compost and final disposal of all by-products and remaining materials in an environment friendly manner.

- 5) Coordination, Collection, and transportation of waste is not in the scope of this work.
- 6) Vendor to do post Segregation of the preliminary source segregated Waste.
- 7) Shredding and Dewatering of waste.
- 8) Training to the operating team.
- 9) The contractor shall ensure that the compost generated at the plant shall meet FCO (Fertilizer Control Order) norms as per the Fertilizer (Control) Order, 1985.
- 10) Requirement for commissioning of plant: The contractor shall submit the details of land, water, and electricity requirements for setting up the plant.

The contractor shall comply with all the relevant environmental laws. Necessary emission control mechanism shall be adopted by the contractor. The technology used shall not emanate foul smell and disturb the environment.

1.3 QANTIFICATION OF SOLID WASTE

The total solid waste generated from the IT Park Building will be 450 kg/day waste for phase 1.

Solid waste generated from the proposed project can be broadly categorized into:

- Biodegradable Waste viz. Food Waste, Garden Waste, etc.
- Non-Biodegradable Waste (Recyclable Waste & Combustible Waste) viz. Plastic, Papers, Metals, cloths, glass, broken furniture etc.
- Inert viz. earth, dust, ceramics, etc.

The biodegradable waste is assumed to be 40% by weight of the total solid waste. Non-biodegradable waste is assumed to be 60 % by weight of the total solid waste generated in the proposed project.

2.0 PROCESS DESCRIPTION

2.1 SEGREGATION OF WASTE AT SOURCE

Segregation is the separation of Municipal Solid Waste into groups of organic, inorganic, recyclables etc. Segregation of solid waste is the first step to effective management of solid waste. Depending upon the nature of the solid waste, it should be segregated as far as possible at the source of generation. Wet waste and dry waste will be collected separately at all waste generation points in IT Park building. The facility management team will educate and spread awareness about the waste segregation at source and will take necessary measures to ensure compliance at all levels.

As per Municipal Solid Wastes (Management and Handling) Rules, 2016, it shall be the responsibility of generator of wastes to avoid littering and ensure delivery of wastes in accordance with the collection and segregation system and hence, every individual should ensure that the waste is unmixed and place the biodegradables and recyclables separately.

2.2 COLLECTION AND TRANSPORTATION OF WASTE

As the project is based on office premises, a systematic waste management system is in operation. The sweeper diligently separates waste into dry and wet categories during two daily collection rounds. The sorted waste is then placed into specific containers or bins. These containers are subsequently transported to the basement area for centralized storage in the compound's designated garbage area. From there, the waste proceeds to further treatment. This organized approach ensures effective waste segregation and promotes a cleaner and more environmentally conscious workspace.

The collection system is divided into primary and secondary collection system. A primary collection system consists of collection of waste from all the floors and put into secondary collection container/bins.

The various steps involved in effective waste management system are:

- a) Segregation of solid waste at source is the first criterion for effective waste management practices. Depending upon the nature of the solid waste, they should be segregated as far as possible at the source of generation.
- b) The segregation of waste should be facilitated with the help of colour-coded bins. Separate bins would be provided for dry and wet wastes in the TIDEL IT Park.
- c) Generally, Green is for Biodegradable, Blue/Yellow for Non-biodegradable waste.
- d) Colour coded bins of 120 and 600 liters capacity respectively for primary and secondary collection shall be provided as per the requirements.
- e) Storage capacities of the bins have been calculated to store 1 days of waste generated.
- f) There shall be two tier system of waste storage. 10-liter bins inside the buildings as per the requirement (or close to waste generation source) and 120 liters at primary collection at each unit. From 120 liters bins the waste will be transported to the secondary collection bins of 600 liters capacity for storage and further transport to the waste handling facility.
- g) There shall be a solid waste collection team who will collect from those primary nodes during off peak hours by common collection bins.
- h) From these storage places:
 - Organic waste shall be diverted to organic waste treatment plant/units.
 - Inorganic- Recyclable material, depending on the volumes, can be sent to recycling agency on weekly/ monthly basis.
 - Inorganic – Inert material can be sent for disposal on designed interval through local waste disposal agency.
- i) Based on the development and phasing, the storage chambers and equipment's for treatment can be expanded on modular basis at this designated area.

2.3 ROAD SWEEPING AND CLEANING OF PUBLIC AREAS

Roads present in the TIDEL IT Park area should be swept daily. Colour coded litter bins should be kept along the roadside and walkways for collecting garbage generated along the roadside. Colour coded bins should be provided to collect the biodegradables and recyclables separately.

Removal of waste from these litter bins should be done by sweepers and the contents transferred into the bins.

2.4 MECHANIZED COMPOSTING (ORGANIC WASTE CONVERTER) SYSTEM

Composting is a process of controlled decomposition of the organic waste, typically in aerobic conditions, resulting in the production of stable humus like product, compost. Considering the typical composition of wastes and the climate conditions, composting is highly relevant in India. The decomposition process takes place in the presence of air and results in elevated process temperatures, the production of carbon dioxide, water, and stabilised residue, known as humus. A high degree of stabilisation can generally be achieved in 3-6 weeks; however 'curing' of the humus is normally carried out. For composting to occur in an optimum manner, five key factors need to be controlled; temperature, moisture, oxygen, material porosity and Carbon: Nitrogen ratio. Compost, the final product, because of its high organic content, makes a valuable soil conditioner and is used to provide nutrients for plants. When mixed with soil, compost promotes proper balance between air and water in the resulting mixture, which further helps reduce soil erosion, and serves as a slow-release fertilizer.

Process:

Mechanized composting is simple & practical process because the most unpleasant fraction of the waste stream - the food waste, is being dealt with hygienically on a daily basis. You empty your food waste into Composter every day through the hopper. Add absorbent (Saw dust) and microbial composting agent along with waste. The chopper at the inlet chops the material to increase the surface area & make the waste homogenous. This homogenous mixture is passed on into the drum.

The drum having agitator inside is rotating at very slow speed. The waste material due to its rotary action will fall down from the baffles and get automatically aerated.

The average process time inside the machine is 10-15 days. The aeration and turning is done automatically which means that the natural decomposition process works perfectly from start to finish. The finished compost is automatically sent out. The composting process takes place in an in-vessel composting unit so there are no unpleasant odours on-site. Automatic drum composter with inbuilt crusher to make excellent compost from domestic/industrial food waste.



Figure 1: Typical OWC (Organic Waste Composting) Plant

2.5 WORKING PRINCIPLE

- Compositing is nature's way of recycling by decomposition
- Organic Waste Converter system enhances this process of decomposition by providing favourable conditions of food, water, and temperature to the compositing micro-organisms to grow and multiply.
- These micro-organisms multiply rapidly and create nitrogen rich compost.
- In this process of decomposition, the temperature rises and kills the harmful disease-causing pathogens and also speeds up the compositing process.
- Deposit food waste along with 0.1% composting culture and 5% sawdust depending on the moisture of the wet waste.
- Mixing, curing is automatically done by the machine.
- Compost keeps collecting In a bag at the rear end.
- Process retention time min 10 -15 days.

2.6 SAILENT FEATURES FOR THE PROPOSED PLANT

- The Vendor to supply, Installation, testing and commissioning of a Mechanized (in-vessel) composting plants of capacity 1000 kg/day for purely biodegradable (green waste) material. The plant shall run in full capacity and capable of achieving the daily throughout of approx. 250-300 kg/day as specified above. It is the contractor's obligation to size the equipment in accordance with the operating requirements of the plant.
- The area available for installation of treatment plant is (15.85 x 7.5) sqm approx.
- The system should be fully automatic and ensure hassle free operation in the longer run.
- The system should not generate any bad odour, pollution, and further garbage. The system should be eco-friendly and harmless to humans and animals. The reduction in volume of waste should be around 70-80% with a manure production of 20-30%.
- The Organic Waste Converter machine shall consist of an automatic rotational composter with a loading screw. The raw material shall be loaded automatically. Following the raw material loading process, the in-vessel composter shall be able to process and automatically unload the final product after a predetermined time during which the biodegradable material would have decomposed to compost. The unloaded compost shall pass through a sieve mechanism, with sieving size ranging between 3-4mm. The tenderer must ensure that the compost produced is

of good quality and shall meet the FCO standards and suitable for sale.

- The vessel where the composting takes place shall be leak proof. No leachate generated shall leak onto the floor.
- The equipment shall also include another separate shredder for the shredding of tree prunings to be mixed with the green waste for better quality compost. The prunings should not have a diameter bigger than 30mm.
- The composter shall include turning mechanism to aerate the waste in order to accelerate the composting process. Mechanisms used to mix/aerate the composting material (waste) should be made from stainless steel 316.
- Any steel parts that form part of the composter shall be galvanised to reduce corrosion problems.
- The machine shall have a compost unload or discharge system complete with a selector switch or controller for the selection of either manual or automatic unloading depending on the operator's need. Compost should be unloaded in a leakproof container.
- The Composter shall be a ready-to-plug in equipment including microprocessor process controls and an electric control panel with both automatic and manual functions.
- The electrical motor shall operate on 420V AC, three phase, 50Hz electric supply.
- The Organic Waste Converter system shall include a mechanical ventilation system covering all the area of the composter to capture vapor and gases generated from the waste. The extracted waste gases shall be filtered through a bio-filter or carbon filter before being released into the atmosphere in order to eliminate odours. The mechanical ventilation system shall include an indicator to give a warning when the filters need to be replaced.
- Condensation shall be collected by means of condensation traps, before passing through the mechanical ventilation system to avoid electricity problems and corrosion. The condensate shall be collected in a leakproof container capable of storing leachate material. The condensate container shall include an indicator to give a warning to the operator when the condensate tray or container is full and needs to be emptied.
- The composter shall include any sound absorbing material and vibration eliminators required to ensure that the overall noise level of the unit is within 70dB.
- The residence time of the material within the in-vessel composter until the final compost is produced and ready for use should be 10 – 15 days. The compost shall not need any further curing.

- The machine shall have both visual and audible warnings that would help the user notice the fault and take immediate action. The motor used for the turning mechanism, the feeding system and any lids should have the necessary safety features.

Materials suitable for composting shall include the following waste fractions:

- Green Waste such as vegetable remains.
- Food Waste excluding animal biproducts.
- Paper and tissue paper.
- The equipment shall be reliable, capable of achieving consistent, pathogen free compost within the residence timeframe.
- The equipment shall provide sufficient oxygen for aerobic degradation, while minimizing cooling of the compost through excessive airflow. Hence air blown into the compost should be warm. The composter should facilitate a sustained temperature in desired degrees Celsius for three days to achieve sanitisation.
- The contractor must ensure that all biodegradable material placed in the composter is sufficiently treated, and that no short-circuiting between the raw material and treated product can occur.
- Any electrical boards attached on the outer structure of the composter shall be IP65.
- The Auto composter shall maintain the optimum relevant parameters of the biological treatment including moisture, temperature at different points in the drum and turning frequency for composting. Values of these parameters should be continuously measured and recorded. These parameters should be easily seen on the control panel of the machine. The equipment should have the facility to be connected to a remote PC terminal.
- Software of the equipment, manuals and schematics of connection cables shall be provided on a CD.
- The vessel where the composting is taking place shall be accessible through side manholes to enable manual sampling and measurement of temperature and moisture content inside the compost. .
- The in-vessel composter shall include means of screen cleaning and easy access for cleaning and maintenance purposes
- The successful contractor shall be responsible for the installation and commissioning of the equipment and shall provide all technical assistance required during the operation of the in-vessel composting unit installed.

- Commissioning will be considered as successful only when the machine proves that:
- The plant can treat 1000 kg (biodegradable waste) per day;
- The compost produced will be of good quality and shall also comply FCO norms;
- The compost will be produced in not more than 15 days from when the organic material is inserted in the composter;
- No leachate is generated from the drum during its operations.

Training

- The tenderer shall adequately train the client to perform the following tasks:
- Assemble and dismantle the plant (where applicable).
- All elements of the systems operations, from the supply of the feed material, till the collection of the compost material.
- Cleaning and maintenance procedures.
- Safety procedures
- All relevant procedures including manuals are to be provided in hard and soft copies (two of each) upon commissioning.
- The offer shall include a five-year maintenance programmed with a maintenance agreement offer. The Contracting Authority may accept or refuse the maintenance agreement.
- The successful tenderer shall provide a service of an on call assistance in case of emergency.
- The bidder shall provide a spare parts list together with a spare parts offer. The tender shall guarantee the availability of spare parts for 10 years from the installation of the equipment.
- One Weighing scale of 1 to 50 kg capacity (ISI approved make) shall be provided.
- The Contractor shall furnish to the Contracting Authority a maintenance manual, operational manual, installation manual, electrical drawings, mechanical and structure drawings of the machine.

3.0 TECHNICAL SPECIFICATION FOR COMPOSTING SYSTEM (DATA SHEET)

Sr. No.	Description	Technical Specifications
1	Name of Equipment/ Make of the machine	Organic Waste Converter (Mechanized In vessel Composting system)
2	Model No.	To be filled by Vendor
3	Quantity of Biodegradable Waste	450 kg/day (for Phase 1)
4	Capacity of In vessel composter to be provided	1000 Kg/day (for Ultimate Phase)
5	Nature of Waste	Organic (Biodegradable)
6	Output	Organic Manure
7	Area Available (approx.)	15.85m x 7.5m
8	Addition of Saw Dust & Culture	15-30 % of total waste input (subject to wetness of waste)
9	Warranty	12 Months from the date of invoice. Manufacturing Defect – All Operational Issues for 12 months
10	Power consumption (KW)	To be filled by Vendor
11	Compost machine size (l*b*h) (ft.)	To be filled by Vendor
12	Material of Construction of Composting machine drum and body	Stainless Steel (SS 304)
13	Material of Construction of mixing shaft and blades	Stainless Steel (SS 304)
14	Rotating arms Motor make	ABB / Siemens / CG
15	Volume reduction in %	To be filled by Bidder
16	Composting time	10 – 15 days
17	Composting method	Aerobic
18	Operation	Fully Automatic
19	Control panel system	HMI – Touch pad with programming facility
20	Shredder requirement	Inbuilt shredder
21	Capacity of shredder (Kg/hr)	To be filled by Vendor
22	Power consumption (KW)	To be filled by Vendor
23	Material of Construction of outer	Stainless Steel (SS 304)

	body	
24	Material of Construction of blade	Stainless Steel (SS 304)
25	Any additional details	To be filled by Vendor
26	Curing system	Inbuilt
27	Control Panel	Programmed pre-set function
28	Waste Input and Manure output	Separate Door for both operation
29	Blower	As per process requirement
30	Air warming system	As per manufactures standard and process requirement
31	Segregation table	1 no
32	Weighing scale Electronic Weighing Scale, Capacity 100 Kg	1 no
33	Bag packing machine Small bag packing machine to pack compost bag, suitable to pack 25-50 kg bag	1 no
34	Manual Handling Trolley: Stainless Steel Platform Trolley Load Capacity 100 to 150 kg Strong, rigid, steel handle for secure manoeuvrings of loads 4 ball bearing wheels for easy and safe steering. Compact design for easy storage.	1 no
35	No of Waste storage bins (for primary storage at treatment facility) – 120 Lt. capacity	2 no's + 2 no. standby
	No of Waste storage bins Wheel mounted (for secondary storage at treatment facility) – 600 Lt. capacity	4 no's + 2 no's standby Note: 2 bins for wet waste and 1 bin as standby. 2 bins for dry waste and 1 bin as standby.

	Specifications: HDPE/PVC Storage bins with Wheel mounted or trolley mounted. Waste Garbage Bins shall be colour coded & Heavy Duty Sunproof Tight-fitting, overlapping lid to help contain odors. Colour : Green, Blue & Yellow	

4.0 OTHER GENERAL INSTRUCTIONS

- All fabrication, erection works including electrical works shall be carried out by the contractor. The works should be carried out safely so that the system remains in working condition throughout its life cycle.
- The manure generated in the process need to be weed-free and rich in organic carbon contents. Hence, it will be a better soil-conditioner than any other organic manure.
- The contractor shall ensure that the compost generated at the plant shall meet latest FCO (Fertilizer Control Order) norms
- The system to be designed as per the Municipal Solid Waste (Management and Handling) Rules 2000,
- The system should be easy to operate and maintain. It should be clean and generate no mosquito breeding. Electricity consumption should be as minimum as possible. It should completely convert the bio degradable waste to manures ready for use without further processing.
- The compost shall be stored temporarily at the site in gunny bags and shall be packaged in 25/35 kg bags for further transportation.
- The firm will obtain all approvals / sanctions/ clearance from local / state /central Govt. authorities, if any, required for execution of the system.
- The contractor will test the manure so generated from the plant in laboratory and submit the certificates.
- The system should be able to run in manual mode also in the event of failure of any motors so as to ensure the processing of the waste.

TECHNICAL SPECIFICATIONS FOR ELV SYSTEM

CONTENTS

1.1 General Requirements	3
1.2 Intelligent Fire Detection and Alarm System.....	14
1.3 Digital Public Address System	49
1.4 Security Access Control System	56
1.5 IP CCTV Surveillance System.....	104
1.6 Integrated Building Management System - IBMS	137
1.7 Data Networking & Telecom Services - ICT	222

1.1 General Requirements**1.1.1 General Scope of Works:**

Work to be performed under this contract consists of supply, installation, testing, commissioning & warranty of below listed system & equipment in other section of this document

- Intelligent Addressable Fire Alarm system - FAS
- IP Based Public Address System - PAS
- IP CCTV Surveillance System – IP CCTV
- Security Access Control System - ACS
- Parking guidance & Management system - PGMS
- Integrated Building Management System - IBMS
- Data Networking & Telecom system – ICT
- **Intelligent Addressable Fire Alarm system - FAS:**
 - The proposed Fire Alarm System shall comply with NBC-2016 requirements & NFPA-72 standards.
 - Analogue Addressable intelligent Fire Detection & Alarm System with Integrated Digital Voice Communication System is proposed.
 - Multi-Criteria Detectors are proposed throughout the building. Heat / Thermal Detectors are considered in Kitchen area. Special Application detectors like Duct detectors (AHU's Return air duct) / Hydrogen Detectors (Battery Room) / Gas Leakage detectors (Gas Bank) considered.
 - Modules like Manual Call Station, Input Monitor Module, Output Control Relay Modules are considered as per the requirement of project based on the application.
 - Aspiration Smoke Detection system considered in IBMS Server Room and the same to be integrated with Fire Detection System, Gas Suppression System & BMS.
 - Fire Alarm Panel shall be installed at Ground Floor Fire Command Room (FCC Room) as per the guidelines given in NBC.
 - Graphical User Interface with workstation shall installed at FCC Room as per the guideline given by NBC for ease of operation.
 - Fire Alarm System to be integrated with Public Address System, Access Control System, HVAC System, Lift / Escalator, BMS within the building level.
- **Public Address System:**
 - The proposed Public Address System is complied with NBC-2016 requirements & EN-54 standards.
 - Digital Public Address System is considered. The Main Equipment's like Multi-Zone Controller, Digital Amplifiers, Microphone Console shall be interfaced through communication cable.
 - Field Speakers to be interfaced through 2 wire communication methodology
 - Public Address System shall be interfaced with Fire Alarm System within the building level for ease of operation.
- **Closed Circuit Television (CCTV):**
 - CCTV is considered here for building Surveillance Purpose. IP CCTV System is considered with latest market trend technology as per the site requirement and building application.

- All Cameras are considered here are combination of 5MP resolution with latest CCTV Artificial Intelligence Algorithm to monitor the building in terms of security surveillance aspects.
- Cameras are considered in all the critical room like IBMS server room, FCC room and all hub rooms, passage, lift, staircase, utility rooms, electrical rooms, HVAC Rooms, Car / Bike Parking Areas, Building External Perimeter etc. and the cameras shall be connected through LAN Network. The power shall be driven from Network Highspeed Switches through Power over Ethernet (PoE).
- Layer 2 Network PoE Switches shall be placed in Floor wise HUB Room and the same shall be connected to L3-Core Switch with redundancy through OFC Backbone.
- The storage retention is considered here with 45days with Server based / NAS based storages Array box for Main Server Recording and the 15days data retention for Failover Server Recording.
- All the cameras shall have edge-based analytics and they shall be enabled at the time of commissioning as per the tender requirement. Server based Analytics shall be considered if camera does not have edge-based analytics.
- CCTV Control & Monitoring station is considered in FCC Room and the Storage Devices, Servers with redundancy are considered in IBMS Server Room.
- **Security Access Control System:**
 - Access Control System considered here to secure the places to avoid the unauthorized entry to the building.
 - Smart-Card based Access Control System is considered for Utility Rooms, Electrical Rooms, UPS Room, TIDEL Offices, Entrance Control Equipment's, HVAC Rooms etc. within the building.
 - Bio-metric based Access Control System is considered for Critical Rooms like HUB Room, TSP / ISP Room, IBMS Server Room within the building.
 - Master IP Based Access Controller is considered in each floor and the field equipment's shall be connected to Reader module and the reader module shall be interfaced with Master Controller.
 - The Access control System is proposed for throughout the building and the same shall be interfaced through LAN connection to connect the backbone.
 - Electro Magnetic Lock is considered as per the Door closure and related accessories with Cables, Conduits, Cable tray etc considered.
 - Access Control System Server with Redundancy is placed at IBMS Server Rooms and Operator Workstation is placed at FCC Room.
 - Access Control System Software with multiple features like General Access Control / Attendance & Monitoring / Vehicular Access Control is considered.
 - The proposed Access Control System shall be modular and scalable in case any other module to be added for future services enablement with limited to OEM availability.
 - Perimeter entry & exit security considered by using Boom Barrier & Automatic Number Plate Recognition for Vehicular Movement and the Physical security shall be done through Baggage Scanning, Door Frame Metal Detector (DFMD) and Manual Movement shall be monitored through Swing Barriers at Ground floor Entrance Foyer.

- Swing Barriers is considered in Ground Floor Entrance Foyer and the same shall be controlled / interconnected with Access Control System. Minimum number of required Smart Card is considered for Access Control System operation at this tender.
- The Swing Barrier shall have inbuilt QR code reader for enabling the access to the visitors. The QR Code shall be generated from access control software and the same shall be sent through Push/E-mail/Printable format.
- **Integrated Building Management System:**
 - Integrated Building Management System (IBMS) is considered for this project as per the requirement which will enable the building rated LEED – Platinum requirement.
 - The proposed BMS DDC Controllers shall have compatibility to connect directly with cloud server for ease of operation. In case any failure shall be happened in physical server, the BMS – DDC Controllers shall push / pull the data from the Cloud Server and the operator shall be monitored / control the Building Operation through Cloud BMS Software Graphical Station.
 - The following Sub-systems are considered under IBMS to control & Monitoring.
 - Control & Monitoring of HVAC Lower & Higher side Equipment's with Energy Conservation.
 - Control & Monitoring of Ventilation & Pressurization Panels
 - Tenant energy consumption and Billing System by using BTU Meters / Water Meter / Gas Meter / Energy Meters etc.
 - Monitoring of Firefighting & PHE System
 - Monitoring of Electrical Systems like HT / LT Panels, DG, Transformers, Energy Meters, UPS, Solar System, EV Charging Station etc.
 - Monitoring of Low Voltage System like Fire Alarm System & Aspiration Smoke Detection System, Public Address System, CCTV & Access Control System, Gas Suppression System and Critical Room System like Water Leakage & Rodent Repellent System.
 - All the above system shall be interfaced with DDC Controllers through Hard wired and Open Control Protocol like BACNet / IP, Modbus, M-Bus, LonWorks and KNX lighting Control Protocols etc.
 - IBMS Server with Redundancy is considered in IBMS Server Room to install the IBMS Server Software and the Operator workstation with Client Software is considered in FCC Room for ease operation.
 - Cloud Server shall be subscribed by TIDEL Park, and the Software installation shall be done by Successful Contractor. The cost of the software shall be included in the BMS Software itself.
 - DDC Panels are considered in utility rooms as per the requirement and the same shall be interfaced with LAN Connectivity to connect within the building Backbone.
 - All the required Field Sensors, accessories with cables, conduits and Cable trays are considered to complete as per project requirement.
- **Data Networking & Telecom System (ICT):**
 - Integrated Data Networking & Telecom System has been proposed to provide the high-speed internet, telecom services to entire building.

- The proposed ICT system shall be survived the common networking facility for Data Networking, Telecom works, CCTV, Access Control System, BMS Works, Car Parking Guidance System, IP PA System etc.
- The networking topologies has been considered Layer-3 (L3) Core Switch (Fiber Link Switch) with N:N redundancy, Layer-2 (L2) PoE+ Switches with Copper Distribution and the same shall be connected with L3 switch through OFC backbone. However, the external networking shall be connected with industrial grade 8Port PoE+ Rugged Switches and the same shall be interlinked with above backbone through OFC.
- Passive Components like OFC Backbone, Copper Distribution is considered as per the Project requirement and its application.
- CAT6A Copper distribution is considered for all the nodes of Data Networking, Telecom works, CCTV, Access Control System and BMS Works. Also 25 years stability certification shall be provided by the OEM for all Passive cabling components from field to Switching side. The certificate shall be issued to the name of TIDEL Park, Madurai.
- IPABX System proposed for telecom functional. The proposed System shall have combinational Analog & IP Telephonic System as per the project requirement.
- Analog telephonic system shall be interfaced through Multi-Pair Telephone Cables from MDF to IPABX Machine and field to MDF shall be CAT6A cable.
- The scope of works limited to provide Router, Network Management System, Switching Part, Passive Components Part as per the detailed BoQ.

1.1.2 Specification key notes

- This specification is intended to set out in general the minimum requirements & standards of installation for various units of equipment & work it covers. Provision set out or claim made in the successful tender which are in excess of or improved upon basic requirements of specification shall unless otherwise determined by client become part of requirements of specification whether or not they are subsequently incorporated in addenda to the specification.
- Client shall be the sole judge of what constitute an improvement upon or exceeds the requirements of specification.
- Specification shall be read in conjunction with tender drawings (as per drawing schedule) and are intended to be mutually explanatory and complimentary to one another. All works & specifications called for shall be fully executed & complied within totality.
- Entire system shall be engineered by contractor based on guidelines furnished in the specification, various codes / standards with good engineering practice.
- Specification also includes supply, erection & commissioning of spares as specified along with special tools & tackles.
- This document also makes it obligatory to contractor for arranging & obtaining necessary clearance / approval from all local / statutory authorities.
- It is not intent to completely specify all details of design & construction herein. Nevertheless equipment & installation shall confirm to high standard of engineering, design and workmanship in all aspects and shall be capable of performing continuous satisfactory operation & acceptable to purchaser as well as to various statutory authorities. In case of any violation of above contract,

purchaser reserves right to change / reject / modify the equipment / system during detail engineering.

- Supplies & services to be covered under this tender specification & conditions thereof are detailed in subsequent sections of specification. In case of conflict among various sections, subsections, documents, drawings same shall be referred to purchaser whose decision shall be final & binding to bidder.
- Successful bidders shall be submitted the OEM technical datasheet of all the items as mentioned in the Bill of Materials and highlight the considered parameters as per the tender specifications.
- The document shall be rejected without any reason if the parameters of technical datasheets are not highlighted. However, the technical requirement shall be complied with compliance document. Deviation shall not be accepted and same shall be rejected.
- The above submissions to be applicable for all IBMS & ELV Works.

1.1.3 Shop Drawings

- Upon award of tender, contractor shall immediately prepare & submit the shop drawings to consultants for approval. All plant & equipment layout drawings with full details shall be submitted within designated time by project team. Detailed calculations shall be submitted where applicable. All equipment & materials proposed shall be submitted for approval.
- Shop drawings shall cover complete details for the following but not limited to:
- Dimension of panels, equipments & accessories that include detailed drawings necessary to finalize superstructure requirements.
- Equipment room layout showing all clearances for operating, servicing & sufficient details to ensure that provision made in working drawings shall be adequate & satisfactory.
- Control equipment, system wiring and control diagrams and power requirements.
- Hangers & supports
- Foundations details
- Chases, openings in walls, floors, roof slabs & beams
- Piping, ducting & electrical cable runs.
- These layout drawings shall be generally based on consultant GFC drawings, modified only as required to suit specified materials & equipment to be provided, to fit in with latest available information on building construction details & requirements of other services & equipment and to incorporate any improvements proposed by the contractor.
- Drawings shall be drawn by fully qualified draughtsman with experience in relevant installation works. Drawings shall be done in ink & shall be neat & clearly legible.
- All drawings shall be drawn in same scale as the consultant drawings. Details shall be drawn in larger scales. Wherever applicable, legends/symbols shall be followed as per consultant drawings & all other symbols shall confirm to acceptable local drafting practice.
- Legend for all symbols shall be shown on every drawing.
- Initial submission of shop drawings shall be in soft copy format. Hard copies shall be submitted after the approval.

- Upon approval of drawings, contractor shall deliver four (6) copies of each approved drawing to the PMC/Employer for the purpose of contract administration.
- Drawings shall be submitted in ample time for review & approval by consultant & no work shall be carried out until such drawings are approved.
- Inspection of shop & working drawings is not to be considered as a guarantee of measurements or building conditions. Where drawings are inspected & approved by the PMC/Employer, such approval does not in any way relieve the contractor neither from his responsibility nor from the necessity of furnishing material or performing work required by drawings & specification which shall in the event of a dispute, take precedence over shop drawings.
- Schedule of submission of shop drawings shall be submitted for approval not later than 2 weeks after award of the Sub-contract.
- Successful Contractor shall be discussed with design consultant and get the clarity of List of Supporting document / drawing to be submitted as part of shop drawing submission. The same shall be applicable for all IBMS & ELV Works
- All the ELV & IBMS Works shop drawing shall be submitted by Successful Contractor with the following supporting documents to get the consultant approval. However, each sub system drawing shall be provided separately with each equipment connection / loop connection / node connection / Horizontal Cable Tray layout / Vertical Riser Cable Tray Layout etc. Successful contractor may reach out consultant to get the clarification prior to proceed the shop drawing preparation.
 - Fire Alarm System:
 - ✓ Each Floor Shop Drawing with co-ordination of RCP.
 - ✓ Single line diagram / Schematic Layout of the project
 - ✓ Typical installation details of all the equipments as per the BoQ
 - ✓ Loop Calculation sheet with inclusive of available spares points
 - ✓ Legend to be marked in the Layout with each floor Quantity
 - ✓ Connection diagram of individual equipments with third party interface
 - Public Address System
 - ✓ Each Floor Shop Drawing with co-ordination of RCP.
 - ✓ Single line diagram / Schematic Layout of the project
 - ✓ Typical installation details of all the equipments as per the BoQ
 - ✓ Zone Calculation sheet with inclusive of available spares points
 - ✓ Amplifier calculation details with spare wattage availability in each type of Amplifier
 - ✓ Legend to be marked in the Layout with each floor Quantity
 - ✓ Connection diagram of individual equipments with third party interface
 - Security Access Control System
 - ✓ Each Floor Shop drawing with cable connection from each device to Reader Module and Access Floor Controller
 - ✓ Single line diagram / Schematic Layout of the project
 - ✓ Typical installation / mounting details of all the equipments as per the BoQ
 - ✓ GA Drawing for Swing Barrier / DFMD / X-Ray Baggage Scanner / Boom Barrier with required civil structural elements
 - ✓ Power socket requirement needs to be submitted as a part of shop drawing
 - IP CCTV Surveillance System

- ✓ Each Floor Shop Drawing with co-ordination of RCP. All the Communication cable measurement to be mentioned in the drawing itself.
- ✓ Each Cameras coverage details shall be indicated in the shop drawing itself with respect to the product selection. However, coverage details shall be complied with DORI (Detection, Observation, Recognition, Identification) as per the OEM specifications.
- ✓ Single line diagram / Schematic Layout of the project with storage device / server element / display element needs to be furnished.
- ✓ All type of Camera mounting diagram as per the BoQ
- ✓ Each Floor Camera Node details shall be submitted.
- ✓ Legend to be marked in the Layout with each floor Quantity
- Integrated Building Management System
 - ✓ Each Floor Shop Drawing with DDC Tag Identification.
 - ✓ Single line diagram / Schematic Layout of the project shall be furnished
 - ✓ All Sensors / DDC / Enclosures mounting diagram as per the BoQ
 - ✓ GA drawing of DDC Controllers, IO Modules and Enclosures Panel / Wiring diagram of each DDC Controller / Selection of IO Points with Spare details to be furnished.
 - ✓ Control Schematic Layout with each IO tag details, and Cable schedule shall be submitted.
 - ✓ Each Floor Node details shall be submitted.
 - ✓ Legend to be marked in the Layout with each floor Quantity
- Data Networking & Telecom Services - ICT
 - ✓ Each Floor Shop Drawing with each Node Identification.
 - ✓ Single line diagram / Schematic Layout of the project shall be furnished
 - ✓ All type of Rack distribution diagram / drawing shall be provided
 - ✓ Each Floor Node details shall be submitted.
 - ✓ Legend to be marked in the Layout with each floor Quantity
 - ✓ Connection diagram of Network Topology / Telecom Topology from the Service Provider to field point shall be provided in detail in the shop drawing.
- General Requirements
 - ✓ Detailed Layout of IBMS Server Room and FCC / IBMS Room Layout with required Operator Station, power socket details, CCTV Display mounting Details, furniture's etc shall be submitted.
 - ✓ External CCTV Cameras Mounting Poles GA Drawing and its required foundation details with proper structural elements, Outdoor type IP65 Enclosure mounting arrangement details shall be submitted.
- Technical Compliance:
 - ✓ The successful Bidder / Contractor shall submit the technical compliance of each equipment technical requirement as prescribed in the tender technical specification while submitting the Technical Datasheet Sheet (TDS) submission for approval of Consultant. The TDS shall not be accepted / reviewed and the same shall be rejected if the data shall be submitted without compliance sheet. Each equipment technical specifications shall be picked from the technical specification and the

same shall be attached with respect to the equipments. This is applicable for entire equipments of ELV System.

1.1.4 Approvals

- All systems shall have proper listing and/or approval from internationally recognized UL - Underwriters Laboratories Inc, IS & NFPA standards.
- Fire alarm panel shall meet modular listing requirements of Underwriters Laboratories, Inc. Each subassembly, including all printed circuits. It shall also include appropriate UL modular label. This includes all printed circuit board assemblies, power supplies & enclosure parts. Systems that do not include modular labels may require to be returned to the factory for system upgrades & are not acceptable.

1.1.5 As Built Drawings & Manuals

- Prior to completion of works & not later than date of practical completion, contractor shall submit to six (6) hard cover bound sets of comprehensive/non-comprehensive operation & maintenance manuals & data sheets published by equipment manufacturers, six (6) hard cover bound sets of "As-Installed" drawings & one (1) set of "As-Installed" drawings in polyester film transparency (intermediates) & two (2) sets of "As-Installed" drawings in AutoCAD (latest release) compact discs subject to project managers approval.
- These instruction manuals shall be typed in good quality paper & neatly bound into a manual having rigid covers. A draft shall be approved before final submission.
- Operation manual & as-built drawings shall be bound with hard covers.
- All "As-Installed" single line drawings & control diagram shall be endorsed and signed by the contractor's professional engineer.
- Manuals shall contain & be set out as follows:
- Description of system: This section shall simply but clearly describe the operation of system & equipment.
- Equipment list: Section shall include all major equipment/components complete with makes, models, serial number with technical catalogues (at least one set to be original & others in legible print).
- Spare parts, tools & equipment list: Include manufacturer's list of all recommended spare parts for replacement & special tools & equipment for maintenance used.
- Manufacturer's handbook: It shall include manufacturer's technical literature on all components of installation, particularly as applying to operation & maintenance.
- Technical literature shall include all major equipment, control instruments & equipment used & other related materials.
- Installation Instruction
- Maintenance & Trouble Shooting Instruction
- Equipment Operation Instruction
- Hang-up Instructions
- Equipment/component Suppliers: This section shall comprise a full list of names, addresses & telephone numbers (including after office hours numbers) of all contractors & suppliers of equipment (local and overseas) incorporated in the installation.

- Maintenance & Breakdown Service: This section shall comprise a list of the names and telephone numbers of the company's maintenance & servicing section personnel for normal maintenance & breakdown request.
- In the event of contractor failing to full-fill the aforesaid requirements, project manager shall reserve the right to obtain all the required operating and maintenance manuals by other means and shall deduct all cost incurred thereof from monies due to the contractor.
- In addition, project manager shall forfeit the rights of contractor in relation to further payment and issue of Certificate of Practical Completion will also be withheld until he has so complied accordingly.

1.1.6 Submission of Samples

Samples to be submitted by the contractor shall be for the following but not limited to:

- Fire Alarm System:
Detectors / Modules / Cables / Conduits / Manual Pull Station / Hooter
- Public Address System:
Speakers / Cables / Conduits
- Access Control System:
Smart Card Reader / Smart Cards / Electro-Magnetic Lock / Emergency Door Release / Door Buzzer / Cables / Conduits
- IP CCTV Surveillance System:
All type of Cameras
- Data Networking & Telecom System:
CAT6A IO / RJ 11 IO / GI Box / Face Plate / CAT6A Cable / Patch Cord / OFC Cables / Conduits / Cable Tray
- Building Management System:
All type of Cables / Conduits

In addition to that, the successful Bidder / Contractor shall also submit any other samples as may be required by the PMC / Employer. However, the samples shall be presented in the Plywood Board with product name and BoQ identification number for ease of review by PMC / Employer.

1.1.7 Identification & Labelling

Complete identification & labelling shall be provided for various sections of the work in accordance with Building Control Division & other relevant authority's requirements & to the approval of consultants & project managers

- Additional requirements as requested by fire safety bureau to suit local conditions shall also be complied.

1.1.8 Work By Other Contractors

Following works will be provided by the other contractors:

- All required power supply shall be provided by Electrical Contractors to IBMS Contractor.
- HVAC integration Voltage Free Contact needs to be provided by HVAC System Contractor.
- Flow Switch & Zonal Control Valve connection needs to be done by Firefighting / Sprinkler System Contractor.

- Access Control System & BMS integration needs to be done by IBMS Contractor themselves.

1.1.9 Provision Of Works by Other Trades

- It shall be the contractor's responsibility to advise, check & confirm that the works listed above are provided to his requirements during the course of building construction. Failure on that part, contractor to ensure that any or all of these services are provided will result in contractor having to carry out the respective works at his own expense.
- Contractor shall liaise closely with all other trades for such provisions & communicate all his requirements well in advance & confirm to the construction program.

1.1.10 Co-Ordination Of Work

- Contractor shall check & ensure that all equipments provided are suitable for space allowed. Contractor shall, if necessary, locate these equipments before erection of walls & doors. All abortive work arising from failure to comply with above shall be paid for by the contractor.
- Contractor shall be responsible for the proper & accurate setting out of his work. He shall furnish all necessary information on installation to employer / consultant & civil contractor for work co-ordination purposes. Contractor shall also obtain information on routes of other services from civil contractor before commencing any works to any floor of the building. He shall co-operate with civil contractor & all other contractors on the job & his work shall be suitably pre planned to ensure proper co-ordination with other contractors.
- Contractor shall inform & check with civil contractor on all building works (such as holes, openings, grooves required on floors, walls, etc) that are required to be done as early as possible in order that cut-outs, openings, etc may be formed as the building work proceeds. If the contractor neglects to give the civil contractor reasonable notice & full particulars of any building works required to be done & thereby cause delay or additional expense to be incurred by the civil contractor, contractor shall be required to indemnify the civil contractor against all charges or additional expense incurred in respect thereof.
- Contractor shall inform Employer / Architect / Consultant of any discrepancies in construction details installed on site as compared with "approved" drawings owing to unforeseen site conditions. Contractor shall bear the full cost of rectification if failed to comply with the above clause leads to a malfunction of the system.
- Ceiling pattern as shown in tender drawing is given as a guide only, exact position of ceiling suspended equipment has to be verified on site or good for construction drawings and adjusted, if necessary, without additional cost to the contract.

1.1.11 Testing of All the Systems (ELV & IBMS)

- Contractor shall allow in his tender, price for the cost of all acceptance tests required as hereinafter specified or as required by the authorities having jurisdiction over the installation.
- All water & electricity (temporary or permanent supply) used during the testing & commissioning of systems in this contract shall be borne by the civil contractor including supply, installation & dismantling of necessary piping & associated works.

- All pipe works which are to be encased or concealed shall be tested & approved before they are finally enclosed.
- Contractor shall give the Employer / Architect / Consultant Five (5) days' notice of his readiness to carry out acceptance test & shall submit for his approval a complete & detailed schedule of his tests to be carried out.
- Before commencement of acceptance tests, contractor shall have brought the installation to a state of practical completion & shall have completed all his preliminary testing & adjusted the equipment to its proper running order.
- During testing period no modifications, adjustment or other work on the installation shall be carried out without permission of the Employer / Architect / Consultant. Should there be any contravention of this requirement, the results of all tests completed may be rejected & a retest ordered.
- No acceptance test shall be carried out except in presence of Employer / Architect / Consultant, or the representative appointed for the purpose.
- If the installation fails to perform in accordance with the requirements of specification and/or authorities, Employer / Architect / Consultant may reject whole or any part of it.
- Testing period shall form part of the contract period & no extension of the time will be granted by reasons of any extension of testing period to permit rectification, modification, adjustment or retesting of installation except where testing has been delayed or retesting has been necessitated by circumstances beyond the control of the contractor.
- Contractor shall also be required to conduct all tests as & when requested by the authorities during the free maintenance and guarantee period.

1.1.12 Tools & Equipments

- A complete set of tools & equipment for maintenance shall be submitted to the approval of Employer / Architect.
- Tools & equipment shall be contained in a standing lockable metal cabinet. Two sets of keys shall be provided. Design of cabinet shall be submitted to the approval of Employer / Architect.

1.1.13 Quality Assurance

Manufacturer:

- Manufacturer of extinguishing systems & detection components shall have experience in design & manufacture of similar types of detection systems & who refer to similar installations providing satisfactory service.
- Name of the manufacturer, part numbers & serial numbers shall appear on all major components.
- All detection devices, components & equipment shall be products of the same manufacturer.
- All devices, components & equipment shall be new, standard products of the manufacturer's latest design & suitable to perform functions intended.

Installer:

- Contractor shall show evidence that, company carries sufficient liability & completed operations insurance policy. These limits shall supersede limits required in general conditions of the specification.

1.1.14 Certification By Contractor

- On completion of all performance testing as mentioned in the specification, contractor shall be required to submit all test reports to the PMC / Employer for approval prior to acceptance of such installation. Contractor shall also be required to certify in writing to the PMC / Employer that, the installation is in full compliance with the requirements of specification & codes to which they are designed by a professional engineer/licensed worker.
- Contractor shall engage his own professional engineer to endorse & submit four (4) sets of the original 'Certificate of Supervision' & drawings for the respective installation works one month before system handing over date. All tests & inspections required by the relevant authorities for his installation works for obtaining of NOC of the building shall be carried out by the contractor, if applicable.
- Contractor is to note that his tender price shall deem to include for all testing requirements.
- Certification of practical completion will not be issued unless the clauses as stated above are complied & with the satisfaction of employer / architect / consultant.

1.1.15 Operation & Maintenance

- Contractor shall train the employer's operating personnel in operation & maintenance of the premises.
- Final Handing Over process shall be carried out after successful training session to be conducted by contractor and the same team to be available at site along with Employer's operational team for minimum 3-4weeks and

1.1.16 Maintenance & Guarantee

- Whole of the work to be performed under contract shall be completed & left in running order to the satisfaction of purchaser.
- Performance of whole installation shall be guaranteed to conform to the requirements of this specification. Contractor shall, without additional charge replace any works which prove faulty from workmanship or materials & fully maintain whole installation for a period of 1 year after the commencement of Defects Liability Period.
- Defects Liability Period shall commence from date of issuing certification of practical completion.
- During DLP period, contractor shall be responsible for all costs involved in balancing, setting & adjustment of controls and supplying all test equipment & instruments deemed necessary by employer/architect. During DLP, contractor shall also carry out maintenance work as shown in the schedules.

1.2 Intelligent Fire Detection and Alarm System

1.2.1 System Description

- The facility shall have an emergency voice alarm communication system. Digitally stored message sequences shall notify the building occupants that a fire or life safety condition has been reported. Message generator(s) shall be capable of

automatically distributing up to eight (8) simultaneous, unique messages to appropriate audio zones within the facility based on the type and location of the initiating event. The Fire Command Center (FCC) shall also support Emergency manual voice announcement capability for both system wide or selected audio zones and shall include provisions for the system operator to override automatic messages system wide or in selected zones.

- The system shall support additional, alternate Fire Command Centers, which shall be capable of simultaneous monitoring of all system events. Alternate Fire Command Centers shall also support an approved method of transferring the control functions to an alternate Fire Command Center when necessary. All Fire Command Centers shall be individually capable of assuming Audio Command functions such as Emergency Paging, audio zone control functions, and Firefighter's Telephone communication functions.
- Each designated zone shall transmit separate and different alarm, supervisory and trouble signals to the Fire Command Center (FCC) and designated personnel in other buildings at the site via a multiplex communication network.

1.2.2 Applicable Standards & Product Approvals

The specifications and standards listed below form a part of this specification. The system shall fully comply with the latest issue of these standards, if applicable.

- National Fire Protection Association (NFPA) - USA:
- Underwriters Laboratories Inc. (UL) - USA:

UL 268, 7 th Edition	Smoke Detectors for Fire Protective Signaling Systems
UL 864, 10 th Edition	Control Units for Fire Protective Signaling Systems
UL 2572	Mass Notification Systems
UL 217	Smoke Detectors, Single and Multiple Station
UL 228	Door Closers - Holders for Fire Protective Signaling Systems
UL 268A	Smoke Detectors for Duct Applications
UL 521	Heat Detectors for Fire Protective Signaling Systems
UL 464	Audible Signaling Appliances
UL 38	Manually Actuated Signaling Boxes
UL 1481	Power Supplies for Fire Protective Signaling Systems
UL 346	Waterflow Indicators for Fire Protective Signaling Systems
UL 1076	Control Units for Burglar Alarm Proprietary Protective Signaling Systems
UL 1971	Visual Notification Appliances
UL 2017	Standard for General-Purpose Signaling Devices and Systems
UL60950	Safety of Information Technology Equipment

- Factory Mutual – USA
- Local and State Building Codes.
- All requirements of the Authority Having Jurisdiction (AHJ). The system shall be listed by the national agencies as suitable for extinguishing release applications. The system shall support release of low-pressure Co2.

- The system shall be certified for seismic applications in accordance with the International Building Code (IBC). The basis for qualification of seismic approval shall be via shake table testing.
- The System shall be FM 6320 (Factory Mutual) approved as a Gas Detection system when employed with the 4-20 monitor module and industry standard 4-20 mA gas detectors.

1.2.3 Main Fire Alarm Control Panel (FACP)

- Main FACP or network node shall contain a microprocessor based Central Processing Unit (CPU) and power supply. The CPU shall communicate with and control the following types of equipment used to make up the system: intelligent addressable smoke and thermal (heat) detectors, addressable modules, printer, annunciators, and other system-controlled devices.
- In conjunction with intelligent Loop Control Modules and Loop Expander Modules, the main FACP shall perform the following functions:
- Supervise and monitor all intelligent addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
- Supervise all initiating signaling and notification circuits throughout the facility by way of connection to addressable monitor and control modules.
- Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed.
- **System Capacity and General Operation**
 - The FACP shall communicate on a peer-to-peer, inherently regenerative communication format and protocol. The network shall support communication speed up to 100 Mbps and support up to 200 panels / nodes per network.
 - The control panel shall be capable of expansion via up to 10 SLC loops. Each loop shall support 125 Detectors + 125 Modules / 159 Detectors + 159 Modules / Any Combination of 256 Detectors and modules in which including of 20% spare. 20% spares need to be considered in each loop as per the configuration of Manufactures specification. SLC Loops to be considered Max 1 or 2 per Floor as per the OEM product lines.
 - Single loop cannot be considered for multiple floors. The Fire Alarm Control Panel shall include a full featured operator interface control and annunciation panel that shall include a backlit 600-character liquid crystal display, individual, colour coded system status LEDs, and QWERTY keypad / Larger LCD Touch Screen Keypad QWERTY style alphanumeric for the field programming and control of the fire alarm system.
 - Said LCD shall also support graphic bit maps capable of displaying the company name and logo of either come owner or installing company.
 - All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel.
 - The FACP shall be able to provide the following software and hardware features:
 - Pre-signal and Positive Alarm Sequence: The system shall provide means to cause alarm signals to only sound in specific areas with a delay of the alarm from 60 to up to 180 seconds after start of alarm processing.

- In addition, a Positive Alarm Sequence selection shall be available that allows a 15-second time period for acknowledging an alarm signal from a fire detection/initiating device. If the alarm is not acknowledged within 15 seconds, all local and remote outputs shall automatically activate immediately.
- Smoke Detector Pre-alarm Indication at Control Panel: To obtain early warning of incipient or potential fire conditions, the system shall support a programmable option to determine system response to real-time detector sensing values above the programmed setting. Two levels of Pre-alarm indication shall be available at the control panel: alert and action.
- Alert: It shall be possible to set individual smoke detectors for pre-programmed pre-alarm thresholds. If the individual threshold is reached, the pre-alarm condition shall be activated.
- Action: If programmed for Action and the detector reaches a level exceeding the pre-programmed level, the control panel shall indicate an action condition. Sounder bases installed with either heat or smoke detectors shall automatically activate on action Pre-Alarm level, with general evacuation on Alarm level.
- The system shall support a detector response time to meet world annunciation requirements of less than 3 seconds.
- Device Blink Control: Means shall be provided to turn off detector/module LED strobes for special areas.
- NFPA 72 Smoke Detector Sensitivity Test: The system shall provide an automatic smoke detector test function that meets the sensitivity testing requirements of NFPA 72.
- Programmable Trouble Reminder: The system shall provide means to automatically initiate a reminder that troubles exist in the system. The reminder will appear on the system display and (if enabled) will sound a piezo alarm.
- On-line or Off-line programming: The system shall provide means to allow panel programming either through an off-line software utility program away from the panel or while connected and on-line. The system shall also support upload and download of programmed database and panel executive system program to a Personal Computer/laptop. A single change to one CPU database shall not require a database download to other CPUs.
- History Events: The panel shall maintain a history file of at least last 4000 events, each with a time and date stamp. History events shall include all alarms, troubles, operator actions, and programming entries. The control panels shall also maintain a 1000 event Alarm History buffer, which consists of the 1000 most recent alarm events from the 4000-event history file.
- Smoke Control Modes: The system shall provide means to perform Fire Smoke Control Station mode. This mode controls all dampers, smoke extraction fan, fresh air supply fans, etc during Fire condition. Smoke Control to meet NFPA-92A and 90B and HVAC mode to meet NFPA 90A.
- The system shall provide means for all SLC devices on any SLC loop to be auto programmed into the system by specific address. The system shall recognize specific device type ID's and associate that ID with the corresponding address of the device.
- Passwords and Users: The system shall support two password levels, master and user. Up to 9 user passwords shall be available, each of which may be

assigned access to the programming change menus, the alter status menus, or both. Only the master password shall allow access to password change screens.

- Block Acknowledge: The system shall support a block Acknowledge for Trouble Conditions
- Sensitivity Adjust: The system shall provide Automatic Detector Sensitivity Adjust based on Occupancy schedules including a Holiday list of up to 15 days.
- Environmental Drift Control: The system shall provide means for setting Environmental Drift Compensation by device. When a detector accumulates dust in the chamber and reaches an unacceptable level but yet still below the allowed limit, the control panel shall indicate a maintenance alert warning. When the detector accumulates dust in the chamber above the allowed limit, the control panel shall indicate a maintenance urgent warning.
- Custom Action Messages: The system shall provide means to enter up to 100 custom action messages of up to 160 characters each. It shall be possible to assign any of the 100 messages to any point.
- Local Mode: If communication is lost to the central processor the system shall provide added survivability through the intelligent loop control modules. Inputs from devices connected to the SLC and loop control modules shall activate outputs on the same loop when the inputs and outputs have been set with point programming to participate in local mode or when the type codes are of the same type: that is, an input with a fire alarm type code shall activate an output with a fire alarm type code.
- Read status preview - enabled and disabled points: Prior to re-enabling points, the system shall inform the user that a disabled device is in the alarm state. This shall provide notice that the device must be reset before the device is enabled thereby avoiding activation of the notification circuits.
- Custom Graphics: When fitted with an LCD display, the panel shall permit uploading of a custom bit-mapped graphic to the display screen.
- Group Decision Making by Smoke Detectors: The system shall provide means to link one detector with minimum two more detectors in group decision making. The group of minimum three detectors shall work in tandem to take fast and genuine alarm decision mitigating the risk of false alarm. There shall be no requirement of cross zoning or mandatory sequential address setting in the detectors to achieve this function. This shall be a built-in intelligence in the system to take fast & reliable decision on genuine alarm triggering. The alarm event shall be a result of group of detector chamber readings considered as a consolidated alarm signal.
- ACTIVE EVENT: The system shall provide a Type ID called FIRE CONTROL for purposes of air-handling shutdown, which shall be intended to override normal operating automatic functions. Activation of a FIRE CONTROL point shall cause the control panel to (1) initiate the monitor module Control-by-Event, (2) send a message to the panel display, history buffer, installed printer and annunciators, (3) shall not light an indicator at the control panel, (4) Shall display ACTIVE on the LCD as well a display a FIRE CONTROL Type Code and other information specific to the device.

- NON-FIRE Alarm Module Reporting: A point with a type of ID of NON-FIRE shall be available for use for energy management or other non-fire situations. NON-FIRE point operation shall not affect control panel operation, nor shall it display a message at the panel LDC. Activation of a NON-FIRE point shall activate control by event logic but shall not cause any indication on the control panel.
- Mass Notification Override: The system shall be UL 2572 listed for Mass Notification and shall be capable, based on the Risk Analysis, of being programmed so that Mass Notification/Emergency Communications events take precedence over fire alarm events.
- Security Monitor Points: The system shall provide means to monitor any point as a type of security.
- One-Man Walk Test: The system shall provide both a basic and advanced walk test for testing the entire fire alarm system. The basic walk test shall allow a single operator to run audible tests on the panel. All logic equation automation shall be suspended during the test and while annunciators can be enabled for the test, all shall default to the disabled state. During an advanced walk test, field-supplied output point programming will react to input stimuli such as Control by Event and logic equations. When points are activated in advanced test mode, each initiating event shall latch the input. The advanced test shall be audible and shall be used for Pull station verification, magnet activated tests on input devices, input and output device and wiring operation/verification.
- Control By Event Functions: A zone shall become listed when it is added to a point's zone map through point programming. Each input point such as detector, monitor module or panel circuit module shall support listing of up to 10 zones into its programmed zone map.
- Permitted zone types shall be general zone, releasing zone and special zone. Each output point (control module, panel circuit module) can support a list of up to 10 zones including general zone, logic zone, releasing zone and trouble zone. It shall be possible for output points to be assigned to list general alarm. Non-Alarm or Supervisory points shall not activate the general alarm zone.
- 1000 General Zones: The system shall support up to 1000 general purpose software zones for linking inputs to outputs. When an input device activates, any general zone programmed into that device's zone map will be active and any output device that has an active general zone in its map will be active. It shall also be possible to use general zone as arguments in logic equations.
- 1000 Logic Equations: The system shall support up to 1000 logic equations for AND, OR, NOT, ONLY1, ANYX, XZONE or RANGE operators that allow conditional I/O linking. When any logic equation becomes true, all output points mapped to the logic zone shall activate.
- 100 trouble equations per device: The system shall provide support for up to 100 trouble equations for each device, which shall permit programming parameters to be altered, based on specific fault conditions. If the trouble equation becomes true, all output points mapped to the trouble zone shall activate.
- Control-By-Time: A time-based logic function shall be available to delay an action for a specific period of time based upon a logic input with tracking

feature. A latched version shall also be available. Another version of this shall permit activation on specific days of the week or year with ability to set and restore based on a 24-hour time schedule on any day of the week or year.

- Multiple agents releasing zones: The system shall support up to 10 releasing zones to protect against 10 independent hazards. Releasing zones shall provide up to three cross-zone and four abort options to satisfy any local jurisdiction requirements.
- Alarm Verification, by device, with timer and tally: The system shall provide a user-defined global software timer function that can be set for a specific detector. The timer function shall delay an alarm signal for a user-specified time period and the control panel shall ignore the alarm verification timer if another alarm is detected during the verification period.
- Secure/Access Operation: The system shall have the capability of configuring input modules to monitor status of door contact or other security type sensors. These input modules shall be able to be commanded from the normally 'Secure' state to an 'Access' state. While in the secure state, the module will transmit alarm conditions to the controller, which shall be annunciated on the LCD and LED displays. The modules shall be placed into the Access state either through the LCD display or through predefined operator keys. While in the Access state, all alarms from the module will be shunted. Placing the module into the access state shall cause a discrete LED associated with input point to flash, but no other trouble or disable condition will be annunciated. Change from Secure to Access and reverse shall be transmitted to the central monitoring station on a per zone basis. Systems that cause or indicate a trouble or disable condition are unacceptable.
- The FACP shall be capable of communicating with a Distributed Control System
- **Central Processing Unit**
 - The Central Processing Unit shall contain and execute all control-by-event (including Boolean functions including but not limited to programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory and shall not be lost with system primary and secondary power failure.
 - The Central Processing Unit shall also provide a real-time clock for time annotation, to the second, of all system events. The time-of-day and date shall not be lost if system primary and secondary power supplies fail.
 - The CPU shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems that require the use of external programmers or change of EPROMs are not acceptable.
 - The CPU shall provide an RS-232 interface between the fire alarm control panel and the UL Listed Electronic Data Processing (EDP) peripherals.
 - The CPU shall provide two RS-485 ports for the serial connection to annunciation and control subsystem components.
 - The RS-232 serial output circuit shall be optically isolated to assure protection from earth ground.
 - In the event of CPU failure, all SLC loop modules shall fallback to degrade mode. Systems not offering degrade mode shall offer Redundant CPU. Such degrade mode shall treat the corresponding SLC loop control modules and

associated detection devices as conventional two-wire operation. Any activation of a detector in this mode shall automatically activate associated Notification Appliance Circuits.

- **Display of Fire Alarm Panel**

- The system display shall have 640 Character QWERTY keypad / LCD Touch Screen Keypad. It shall also provide eleven Light-Emitting-Diodes (LEDs) that indicate the status of the following system parameters: AC POWER, FIRE ALARM, PREALARM, SECURITY, SUPERVISORY, SYSTEM TROUBLE, OTHER EVENT, SIGNALS SILENCED, POINT DISABLED, CONTROLS ACTIVE, and CPU FAILURE.
- These characters shall be only for fire alarm / trouble information and not for Logo or other purpose. It shall be UL Listed. Repeater panel displays in FACP is not allowed unless until approved by UL
- The system display shall provide QWERTY keypad / LCD Touch Screen Keypad for ease of operation.
- The keypad shall have control capability to command all system functions, entry of any alphabetic or numeric information, and field programming without the use of any external equipment or laptop. Two different password levels with up to ten (one Master and nine User) passwords shall be accessible through the display interface assembly to prevent unauthorized system control or programming.

- **Loop Card (Signaling Line Circuit) Control Module:**

- The control panel shall be capable of expansion via up to 10 SLC loops. Each loop shall support 125 Detectors + 125 Modules / 159 Detectors + 159 Modules / Any Combination of 256 Detectors and modules in which including of 20% spare.
- 20% spares need to be considered in each loop as per the configuration of Manufactures specification. The Fire Alarm Panel must have a capacity of 3000 detectors & Modules in each Panel with inclusive 20% spares.
- The Loop Control Module shall contain its own microprocessor and shall be capable of operating in a local/degrade mode (any addressable device input shall be capable of activating any or all addressable device outputs) in the unlikely event of a failure in the main CPU.
- Each loop shall maintain 20% spare capacity for future expansion.
- The SLC interface board shall receive analog or digital information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular device.
- Each SLC Loop shall be isolated and equipped to annunciate an Earth Fault condition. The SLC interface board software shall include software to automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector.
- The analog information may also be used for automatic detector testing and the automatic determination of detector maintenance requirements.

- **Network Communication**

- The FACP shall communicate over a peer-to-peer communication network, inherently over a regenerative communication format and protocol. The network shall support communication speed up to 100 Mbps and support up

to 200 Control Panels/ Network Nodes, over a single medium (copper conductor), redundant ring, communication channel for fire alarm, and telephone talk-back system. The system shall support up to 200 such networks in a single system.

- The network card shall have inbuilt Fiber port for terminating Fiber Optic Cable without any third-party converters.
- **Digital Voice Command / Firefighter Telephone Communication Center**
 - The Digital Voice Command Center located with the FACP, shall contain all equipment required for all audio control, emergency telephone system control, signaling and supervisory functions. This shall include speaker zone indication and control, telephone circuit indication and control, digital voice units, microphone and main telephone handset.
 - Function: The Voice Command Center equipment shall perform the following functions:
 - Operate as a supervised multi-channel emergency voice communication system.
 - Operate as a two-way emergency telephone system control center.
 - Audibly and visually annunciate the active or trouble condition of every speaker circuit and emergency telephone circuit.
 - Audibly and visually annunciate any trouble condition for digital tone and voice units required for normal operation of the system.
 - Provide all-call Emergency Paging activities through activation of a single control switch.
 - As required, provide vectored paging control to specific audio zones via dedicated control switches.
 - Provide a factory recorded "library" of voice messages and tones in standard WAV. File format, which may be edited and saved on a PC running a current Windows operating system.
 - Provide a software utility capable of off-line programming for the DVC operation and the audio message files. This utility shall support the creation of new programs as well as editing and saving existing program files. Uploading or downloading the DVC shall not inhibit the emergency operation of other nodes on the fire alarm network.
 - Support an optional mode of operation with four analog audio outputs capable of being used with UL 864 fire-listed analog audio amplifiers and SLC controlled switching.
 - The Digital Voice Command shall be modular in construction and shall be capable of being field programmable without requiring the return of any components to the manufacturer and without requiring use of any external computers or other programming equipment.
 - The Digital Voice Command and associated equipment shall be protected against unusually high voltage surges or line transients.
 - Fire, Voice & Telephone data shall flow through single network cable.
 - The Voice Evacuation System shall be capable of establishing communication between the master voice controller and amplifier over fiber optic cable network without using any third-party media converter.

- Failure of Fire Panel CPU shall not affect the operation of DVC. In case DVC / Amplifiers are controlled by Fire Panel CPU, a separate panel with dedicated CPU shall be considered for each DVC & Amplifier.
- The Fire Fighters Telephone System shall be capable of having minimum 30 Telephones in conference in multiple FFT Risers
- **Switched Mode Power Supply of Fire Alarm Panel**
 - The Main Power Supply shall operate on 120/240 VAC, 50/60 Hz, and shall provide all necessary power for the FACP.
 - The Main Power Supply shall provide the required power to the CPU using a switching 24 VDC regulator and shall incorporate a battery charger for 24 hours of standby power using dual rate charging techniques for fast battery recharge.
 - The Main Power Supply shall provide a battery charger for 24 hours of standby using dual rate charging techniques for fast battery recharge. The supply shall be capable of charging batteries ranging in capacity from 7-200 amp-hours within a 48-hour period.
 - The Main Power Supply shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults.
 - The Main Power Supply shall be power limited per UL864 requirements.
 - The Main Power Supply shall communicate power supply, line voltage, battery status and charger status to the local LCD display. Any abnormal condition shall be annunciated and logged to the system alarm history log.
 - The interface to the power supply from the Fire Alarm Control Panel (FACP) shall be via the Signaling Line Circuit (SLC) or other multiplexed means. Power supplies that do not use an intelligent interface are not suitable substitutes. The required wiring from the FACP to the addressable power supply shall be a single unshielded twisted pair wire.
 - The addressable power supply shall supervise for battery charging failure, AC power loss, power brownout, battery failure, NAC loss, and optional ground fault detection. In the event of a trouble condition, the addressable power supply shall report the incident and the applicable address to the FACP via the SLC.
 - The addressable power supply shall have an AC Power Loss Delay option. If this option is utilized and the addressable power supply experiences an AC power loss, reporting of the incident to the FACP will be delayed. A delay time of zero, two, eight or sixteen hours shall be programmable.
 - The addressable power supply shall have an option for Canadian Trouble Reporting and this option shall be programmable.
 - The addressable power supply mounts in either the FACP back box or its own dedicated surface mounted back box with cover.
 - Each of the power supply's four output circuits shall be programmed- for Notification Appliance Circuit or General Purpose 24 VDC power. Any output circuit shall be able to provide up to 2.5 amps of 24 VDC power.
 - The addressable power supply's output circuits shall be individually supervised when they are selected to be either a Notification Appliance Circuit when wired Class "A" or by the use of an end-of-line resistor. When the power supply's output circuit is selected as General 24 VDC power, the circuit shall be individually supervised when an end-of-line relay is used.

- When selected for Notification Appliance Circuits, the output circuits shall be individually programmable for Steady, March Time, Dual Stage or Temporal.
- When selected as a Notification Appliance Circuit, the output circuits of the addressable power supply shall have the option to be coded by the use of a universal zone coder.
- The addressable power supply shall interface and synchronize with other power supplies of the same type. The required wiring to interface multiple addressable power supplies shall be a single unshielded, twisted pair wire.
- An individual or multiple interfaced addressable power supplies shall have the option to use an external charger for battery charging. Interfaced power supplies shall have the option to share backup battery power.
- **Controls with associated LED Indicators**
 - Emergency Two-Way Telephone Control Switches/Indicators
 - The emergency telephone circuit control panel shall include visual indication of active and trouble status for each telephone circuit in the system.
 - The telephone circuit control panel shall include switches to manually activate or deactivate each telephone circuit in the system.
- **Field Programming**
 - The system shall be programmable, configurable, and expandable in the field without the need for special tools. There shall be no firmware changes required to field modify the system time, point information, equations, or annunciator programming/ information. It shall be possible to program through the standard FACP keyboard all system functions.
 - All field defined programs shall be stored in non-volatile memory. Two levels of password protection shall be provided in addition to a key-lock cabinet. One level shall be used for status level changes such as point/zone disable or manual on/off commands (Building Manager).
 - A second (higher-level) shall be used for actual change of the life safety program (installer). These passwords shall be five (5) digits at a minimum. Upon entry of an invalid password for the third time within a one-minute time period an encrypted number shall be displayed. This number can be used as a reference for determining a forgotten password. The system programming shall be "backed" up via an upload/download program, and stored on compatible removable media. A system back-up disk shall be completed and given in duplicate to the building owner and/or operator upon completion of the final inspection. The program that performs this function shall be "non-proprietary", in that, it shall be possible to forward it to the building owner/operator upon his or her request.
 - The installer's field programming and hardware shall be functionally tested on a computer against known parameters/norms which are established by the FACP manufacturer. A software program shall test Input-to-Output correlations, device Type ID associations, point associations, time equations, etc. This test shall be performed on an IBM-compatible PC with a verification software package. A report shall be generated of the test results and two copies turned in to the engineer(s) on record.
- **Specific System Operations**
 - Smoke Detector Sensitivity Adjust: A means shall be provided for adjusting the sensitivity of any or all addressable intelligent detectors in the system from the

system keypad. Sensitivity range shall be within the allowed UL window and have a minimum of 9 levels.

- Alarm Verification: Each of the intelligent addressable smoke detectors in the system may be independently selected and enabled to be an alarm verified detector.
- The alarm verification delay shall be programmable from 0 to 60 seconds and each detector shall be able to be selected for verification.
- The FACP shall keep a count of the number of times that each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.
- **System Point Operations**
 - Any addressable device in the system shall have the capability to be enabled or disabled through the system keypad or Graphics User Interface.
 - System output points shall be capable of being turned on or off from the system keypad or the video terminal.
 - Point Read: The system shall be able to display the following point status diagnostic functions without the need for peripheral equipment. Each point shall be annunciated for the parameters listed:
 - ✓ Device Status.
 - ✓ Device Type.
 - ✓ Custom Device Label.
 - ✓ Software Zone Label.
 - ✓ Device Zone Assignments.
 - ✓ Analog Detector Sensitivity.
 - ✓ All Program Parameters.
 - System History Recording and Reporting: The fire alarm control panel shall contain a history buffer that will be capable of storing up to 5000 system events. Each of these events will be stored, with time and date stamp, until an operator requests that the contents be either displayed or printed.
 - The contents of the history buffer may be manually reviewed; one event at a time, and the actual number of activations may also be displayed and or printed. History events shall include all alarms, troubles, operator actions, and programming entries.
 - The history buffer shall use non-volatile memory. Systems which use volatile memory for history storage are not acceptable.
 - Automatic Detector Maintenance Alert: The fire alarm control panel shall automatically interrogate each intelligent system detector and shall analyse the detector responses over a period of time.
 - If any intelligent detector in the system responds with a reading that is below or above normal limits, then the system will enter the trouble mode, and the particular Intelligent Detector will be annunciated on the system display and printed on the optional system printer.
 - This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.
 - The system shall include the ability (programmable) to indicate a "pre-alarm" condition. This will be used to alert maintenance personal when a detector is at 80% of its alarm threshold in a 60 second period.

- **System Maintenance Analysis and Reporting**
 - The system shall automatically track NFPA 72 installation and testing requirements for all addressable devices to ensure that every device is functionally tested upon installation and then periodically as required by the Code.
 - If after twelve months any device has not been functionally tested a led shall illuminate on the CPU or Network annunciator indicating the device that needs testing.
 - The system shall automatically track device testing to ensure that a visual inspection is performed at least semi-annually.
 - If after six months a device has not been indicated as "visually inspected" a led shall illuminate on the CPU or Network annunciator indicating the device that needs testing.
 - A hand-held IR tool may be used to interact with each SLC device to indicate that a visual inspection has been performed. The IR device will explicitly identify the device by loop and address to ensure the correct visual inspection has been performed.
 - A comprehensive report shall be available from the laptop programmer which shows a predictive report of all devices that have upcoming testing requirements. These reports shall be configurable as either 30, 60 or 90 days predictive, status, and "all database"
 - Systems that do not automatically track the individual testing requirements of the field devices will not be accepted.

1.2.4 Active Network Repeater Panel

- An Active Network Repeater Panel shall be provided to display all system intelligent points. The Active Network Repeater Panel shall be capable of displaying all information for 200,000 points on the network. Network display devices, which are only capable of displaying a subset of network points, shall not be suitable substitutes.
- The Active Network Repeater Panel shall include a 10" (1024 x 600) Color touchscreen display / QWERTY Keypad. Additionally, the network display shall include environmental adjustment controls to maximize LCD legibility and the ability to scroll events by type. i.e. Fire Alarm, Supervisory Alarm, Trouble, etc.
- The network control annunciator shall have the ability to display multiple events in order of priority and time of occurrence. Counters shall be provided to indicate the total number of events by type.
- The Active Network Repeater Panel shall mount in any of the network node fire alarm control panels. Optionally, the network display may mount in a backbox designed for this use and shall connect to the network over either a wire or fiber interface.
- The network control annunciator shall have an event history buffer capable of storing a minimum of 1000 events in non-volatile memory. Additionally, the Active Network Repeater Panel shall have a fire alarm history buffer capable of storing a minimum of 200 events in non-volatile memory. Systems that do not protect fire alarm events from being overwritten by other events are not suitable substitutes.

- The Active Network Repeater Panel shall include Three USB connection, USB C, USB B Micro, and USB A, industry standard RS-232 ports for UL864 listed printers and CRT's. These peripheral devices shall print or display network activity.
- The network control annunciator shall include control switches for system wide control of Acknowledge, Signal Silence, System Reset, Drill, and local Lamp Test. A mechanical means by which the controls switches are "locked out", such as a key, shall be available.
- The Active Network Repeater Panel shall include long life LEDs to display Power, Fire Alarm, Pre-Alarm, Security Alarm, System Trouble, Supervisory, Signals Silenced, Disabled Points, Other (non-fire) Events, and CPU Failure.
- The network control annunciator shall include a Master password and up to nine User passwords. Each password shall be up to eight alpha-numeric characters in length. The Master password shall be authorized to access the programming and alter status menus. Each User password may have different levels of authorization assigned by the Master password.
- The Active Network Repeater Panel shall allow editing of labels for all points within the network; control on/off of outputs; enable/disable of all network points; alter detector sensitivity; clear detector verification counters for any analog addressable detector within the network; clear any history log within the network; change the Time/Date settings; initiate a Walk Test.
- The network control annunciator shall support an optional Windows based program utility. This utility shall allow the user to create an Active Network Repeater Panel database, upload/download an NCA database, and download an upgrade to the Active Network Repeater Panel executive. To ensure program validity, this utility shall check stored databases for errors. A compare function shall be included to identify differences between databases.
- For time keeping purposes the Active Network Repeater Panel shall include a time-of-day clock.

1.2.5 Network Control Station (NCS) / Graphics User Interface (GUI)

- The NCS / GUI shall utilize a Microsoft(tm) operating system. Each Network Control Station shall be capable of graphically annunciating and controlling all network activity and at least 2,50,000 network points. Network display devices that are only capable of displaying a subset of network points shall not be suitable substitutes.
- Operator workstation shall be recommended by Fire Alarm System OEM with minimum latest technology Operator Station shall be selected. However, the monitor size shall be 22" 4K Resolution.
- The NCS / GUI shall be capable of storing over 100,000 network events in a history file. Events shall be stored on hard disk and shall be capable of back-up storage to a tape drive. The history buffer allows the operator to view events in a chronological order. A filter shall be available for displaying chronological events by operator, date, time, fire alarms, troubles (including security, supervisory and system/device), disabled points/zones, system programming, operator response and operator log in/log out. The ability to print NCS / GUI history files shall also be available.
- The NCS / GUI shall use a Windows(tm) dialog box technology to address, interrogate, control, and/or modify intelligent points on each fire alarm node. This

shall include, and not be limited to: Activating outputs, enabling or disabling points, adding or removing intelligent points, viewing intelligent detector sensitivity levels and modifying point information (custom messages, detector type, verification, day/night selection etc.)

- The NCS / GUI shall include the ability to display system information in a graphical (floor plan) form. Each view, created using standard Windows bitmap files, shall include icons created for intelligent devices.
- These icons shall blink and change to the appropriate programmed icon when an event occurs. When the device has been acknowledged, the icon shall become steady. Once the point has returned to normal, the normal icon is displayed.
- In addition to the graphical representation of the device, the user shall be able to link pictures, documents and sound files to the device. The NCS / GUI shall also provide the ability to auto-vector to the floor plan (screen) of the device that is active. By selecting a device in the graphic presentation, the operator of the NCS shall have the ability to log onto the corresponding node and interrogate the associated intelligent point.
- The NCS / GUI shall have the ability to provide the following information through a Windows(tm) pull down menu: An Event Counter that contains the number of new and total events on the network. The information that is displayed shall consist of Fire Alarms, Pre-Alarms, Security Alarms, Supervisory Alarms, and Troubles. A Detailed Event window that contains all Off-Normal events, both unacknowledged and acknowledged that are present in the system. It shall contain two views, Fire events and non-fire events that shall be user selectable. A Current Event window that shall contain all network and local events as well as system messages with a maximum of 1,000 events displayed. A Disabled Device window that shall contain all disabled devices in the system.
- The NCS / GUI shall have the option, from a Windows pull down menu, to connect to a third-party paging service that allows the NCS to automatically send text-based messages regarding system status to a typical text pager.
- The NCS / GUI shall include help screens, available to aid the user without leaving the selected application screen.
- The NCS / GUI shall be UL-Listed for fire protection (UL864) and burglary (UL1076).
- The NCS / GUI shall interface with other panels as a node in the peer-to-peer network.
- The operator shall be able to monitor the FFT system from GUI software and shall be able to monitor and control Integrated Voice Evacuation System.
- The NCS / GUI shall have a flexible way of assigning operator passwords. There shall be an unlimited number of possible operators, each with specific levels of control. Each operator shall have his/her own password. Operator password and control selection shall be available to a high level "administrator" who shall have complete control over levels of control. If no action has taken place on the NCS after 10 minutes, the current operator shall be logged out and require a new log-in.
- The NCS / GUI shall include an industry-standard RS-232 port for a UL864 listed printer.
- The NCS / GUI shall be a tabletop hardware configuration.
- Interactive Firefighters' Touch Screen Display

- The network will interface and report the individually monitored system's alarm status via a user-friendly Graphical User Interface (GUI) based software.
- The software shall operate under Microsoft Windows 7 or Higher Operating System in as manufactured by Microsoft Corporation.
- The GUI based software must be capable of graphically representing the facility being monitored with floor plans and icons depicting the actual locations of the fire alarm device locations. It shall be capable of mapping at least 2,50,000 network points
- The software shall use a Full HD GUI display capable of showing a large primary floor plan display, a site plan representative of an aerial view of the facility, the first active fire alarm on the system.
- The software shall permit automatic navigation to the screen containing an icon that represents the first fire alarm device in alarm in the event of an off-normal condition.
- The fire alarm device icon shall be visible only when it is in an alarm (or active) condition.
- The software shall display the activated smoke detectors in a time sequence to track smoke progression.
- The software shall allow the importation of externally developed floor plans in Windows Metafile (WMF), JPEG (JPG), Graphics Interchange Format (GIF) and Bitmap (BMP) format.
- The software shall provide a intuitive and easy way to navigate to different screens representing floors and areas within a facility.
- The system shall provide for continuous monitoring of all fire alarm conditions regardless of the current activity displayed on the screen.
- The software shall display "YOU ARE HERE" along with icons representing standard building objects (stairs, elevators, etc) to be shown on the floor plan.
- The software shall allow icons that represent hazardous materials stored in a facility.
- The software shall provide a screen that displays pre-programmed building contact information.
- The software shall provide a screen the displays building occupancy and other general building information.
- The software shall allow a site plan to be imported that shows an aerial view of the facility.
- The software shall display all active fire, supervisory, and security events within an event list.
- Bidders also have the option to propose UL Listed Software with UL Listed Industrial Grade Hardware to achieve this functional requirement.

1.2.6 BMS Integration Gateway Module

- BACNet / ModBus Interface Gateway: The system shall be capable of being interfaced with BACNet / ModBus compliant clients. A BACNet / ModBus interfacing communication shall be available from the fire alarm control panel manufacturer. BACNet / ModBus shall support group of panels with respective data points/ object points. BACNet / ModBus solution shall have UL listing.

- **Webserver:** The system shall support a webserver allowing remote connection via the Internet or Intranet. Authorized users will have the ability to view panel/network history, event status and device properties. The webserver shall also support sending event information via email or text to up to 50 registered users, the web server shall be available from the fire alarm control panel manufacturer.
- **Web Portal Interface:** The system shall be capable of being interfaced with a web portal to integrate with Inspection and Service Manager utilities. The web portal and inspection and service manager utilities shall be available from the fire alarm control panel manufacturer.

1.2.7 System Components Field End

- **Addressable Devices – General**
 - Addressable devices shall provide an address-setting means using rotary decimal switches/Dip switches/Auto addressing
 - Addressable devices shall use simple to install and maintain decade, decimal address switches.
 - Addressable devices, which use a binary-coded address setting method, such as a DIP-switch, are not an allowable substitute. Addressable devices that require the address be programmed using a special tool or programming utility are not an allowable substitute.
 - Detectors shall be intelligent (analog) and addressable and shall connect with two wires to the fire alarm control panel Signaling Line Circuits.
 - Addressable smoke and thermal detectors shall provide dual alarm and power/polling bi-colour LEDs. Both LEDs shall flash green under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady red illumination by the control panel, indicating that an alarm condition has been detected. If required, the LED flash shall have the ability to be removed from the system program. An output connection shall also be provided in the base to connect an external remote alarm LED.
 - The fire alarm control panel shall permit detector sensitivity adjustment through field programming of the system. The panel on a time-of-day basis shall automatically adjust sensitivity.
 - Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72.
 - The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature. Base options shall include a sounder base with a built-in (local) sounder rated at 85 DBA minimum, a relay base and an isolator base designed for Style 7 applications.
 - The system shall also support an intelligent programmable sounder base, the programmable sounder base shall be capable of providing multiple tones based on programming and at a minimum be capable of providing a Temp-4 tone for CO (Carbon Monoxide) activation and a Temp-3 tone for fire activations and be capable of being synchronized with other programmable sounder bases and common area notification appliances; 85 DBA minimum.

- Detectors shall also store an internal identifying type of code that the control panel shall use to identify the type of device (PHOTO, THERMAL).
- Detectors will operate in an analog fashion, where the detector simply measures its designed environment variable and transmits an analog value to the FACP based on real-time measured values. The FACP software, not the detector, shall make the alarm/normal decision, thereby allowing the sensitivity of each detector to be set in the FACP program and allowing the system operator to view the current analog value of each detector.
- Addressable devices shall store an internal identifying code that the control panel shall use to identify the type of device.
- A magnetic test switch shall be provided to test detectors and modules. Detectors shall report an indication of an analog value reaching 100% of the alarm threshold.
- Addressable modules shall mount in a 4-inch square (101.6 mm square), 2-1/8 inch (54 mm) deep customized box. The Box shall be Mild Steel powder coated and finished in Red Colour.
- All the detectors like above false ceiling / True Ceiling / False Floor shall be mounted on 4-inch square (101.6 mm square), 2-1/8 inch (54 mm) deep customized box. The Box shall be Mild Steel powder coated and finished in Red Colour.
- **Intelligent Multi Criteria Detector (Multi-criteria Detector)**
 - The intelligent multi-criteria detector shall be an addressable device that is designed to monitor a minimum of photoelectric and thermal technologies in a single sensing device. The detector design shall allow a wide sensitivity window, 0.5 to 4.0% per foot obscuration. This detector shall utilize advanced electronics that react to slow smouldering fires and thermal properties all within a single sensing device.
 - Designed to meet UL268, 7th Edition
 - The microprocessor design shall be capable of selecting the appropriate sensitivity levels based on the environment type it is in (office, manufacturing, kitchen etc.) and then can automatically change the setting as the environment changes (as walls are moved or as the occupancy changes).
 - The intelligent multi criteria detection device shall include the ability to combine the signal of the thermal sensor with the signal of the photoelectric signal to react hastily in the event of a fire situation.
 - It shall also include the inherent ability to distinguish between a fire condition and a false alarm condition by examining the characteristics of the thermal and smoke sensing chambers and comparing them to a database of actual fire and deceptive phenomena.
 - The rate shall inclusive of all the accessories like backbox for above false ceiling detector, below false floor detectors, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Intelligent Thermal Detectors (Heat Detector)**
 - The intelligent thermal detectors shall be addressable devices rated at 135 degrees Fahrenheit (58 degrees Celsius) and have a rate-of-rise element rated at 15 degrees F (9.4 degrees C) per minute.

- A high heat thermal detector rated at 190 degrees Fahrenheit (87.8 degrees Celsius) shall also be available. The thermal detectors shall connect via two wires to the fire alarm control panel signaling line circuit.
 - ✓ Modern profile with White colour for improved aesthetics.
 - ✓ Advanced thermal technology for fast response.
 - ✓ Fixed temperature model factory preset to 135°F
 - ✓ Rate of Rise model preset to 15°F/min
 - ✓ High temperature model factory preset to 190°F
 - ✓ Low standby current. 200 micro-Amps @ 24 VDC
 - ✓ Two-wire SLC connection.
 - ✓ Rotary, decimal addressing
 - ✓ Dual bi-colour LED design providing 360° viewing angle. LEDs blink green in normal condition and illuminate steady red on alarm
 - ✓ Remote test feature from the panel.
 - ✓ Walk test with address display
 - ✓ Built-in functional test switch activated by external magnet.
 - ✓ Built-in tamper-resistant feature.
 - ✓ Sealed against back pressure.
 - ✓ Optional relay, isolator, and sounder bases.
- The rate shall inclusive of all the accessories like backbox for above false ceiling detector, below false floor detectors, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Intelligent Duct Smoke Detector**
 - The smoke detector housing shall accommodate an intelligent photoelectric detector that provides continuous analog monitoring and alarm verification from the panel. When sufficient smoke is sensed, an alarm signal is initiated at the FACP, and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.
 - The Intelligent Duct Smoke Detector shall support the installation of addressable Photo-electric detector capable or being tested remotely.
 - The rate shall inclusive of all the accessories like backbox for above false ceiling detector, below false floor detectors, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Addressable Manual Pull Station (Push & Pull-down Type)**
 - Addressable manual call point shall send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock and shall be designed so that after actual emergency operation, they cannot be restored to normal use except using a key.
 - All operated stations shall have a positive, visual indication of operation and utilize a key type reset.
 - Manual fire alarm boxes shall be constructed of Lexan / ABS Plastic with clearly visible operating instructions provided on the cover. The word FIRE / Fire Sign shall appear on the front of the stations.
 - The rate shall inclusive of all the accessories like backbox, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Addressable Dry Contact Monitor Module**

- Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panels SLCs.
- The IDC zone shall be suitable for Class A or Class B operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.
- The rate shall inclusive of all the accessories like backbox, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Addressable Relay Module**
 - Addressable Relay Modules shall be available for HVAC control and other network building functions
 - The module shall provide two form C relays rated at up to 3 Amps resistive and up to 2.0 Amps inductive.
 - The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary devices energize at the same time on the same pair of wires.
 - For multiple relays control a module shall be available that provides 6 programmable Form-C relays.
 - The rate shall inclusive of all the accessories like backbox, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Isolator Module**
 - Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC Class A or Class B branch. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC loop segment or branch. At least one isolator module shall be provided for each floor or protected zone of the building.
 - If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.
 - The isolator module shall not require address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.
 - The isolator module shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.
 - If Isolator Bases are proposed, Vendor needs to consider Isolator base for all detectors
 - Serially Connected Annunciator
 - The annunciator shall communicate to the fire alarm control panel via an EIA 485 (multi-drop) two-wire communications loop. The system shall support two 6,000 ft. RS-485 wire runs. Up to 32 annunciators, each configured up to 96 points, may be connected to the connection, for a system capacity of 3,000 points of annunciation.
 - An RS-485 repeater shall be available to extend the RS-485 wire distance in 3,000 ft. increments. The repeater shall be UL864 approved.
 - Each annunciator shall provide up to 96 alarm and 97 trouble indications using a long-life programmable colour LED's. Up to 96 control switches shall also be available for the control of Fire Alarm Control Panel functions. The annunciator

will also have an "ON-LINE" LED, local piezo sounder, local acknowledge and lamp test switch, and custom zone/function identification labels.

- The annunciator may be field configured to operate as a "Fan Control Annunciator". When configured as "Fan Control," the annunciator may be used to manually control fan or damper operation and can be set to override automatic commands to all fans/dampers programmed to the annunciator.
- Annunciator switches may be programmed for System control such as, Global Acknowledge, Global Signal Silence, Global System Reset, and on/off control of any control point in the system.
- An optional module shall be available to utilize annunciator points to drive RS-485 driven relays. This shall extend the system point capacity by 3,000 remote contacts.
- The LED annunciator shall offer an interface to a graphic style annunciator and provide each of the features listed above.
- The rate shall inclusive of all the accessories like backbox, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Addressable Hooters with Built-in Strobe Light**
 - UL/FM/EN/VDS Listed and approved as per applicable codes
 - The unit shall be wall/ceiling mounted, approved colour, suitable for operation on 12V/24V.
 - The Strobe shall have multiple selectable candela settings configured and selected from the FACP.
 - The Hooter cum Strobe unit shall deliver output up to 94 dB at 3m from its installed location & 15dB above ambient noise level for audible annunciation and 110 cd flashing at 1 Hz for visual indication.
 - The sounder/strobe unit shall display the output level at the main control panel. Coordination or synchronization of the Strobes are required for both Audio signal & Visual Signal to comply with ADA (Americans with Disabilities Act) and distinctive signaling across the infrastructure. The required Sync modules to be considered by OEM as part of the overall system
 - The sounder/strobe unit shall display the output level at the main control panel.
 - Hooter and Strobe elements of the combined unit shall have independent activation & deactivation criteria. Hooter shall stop at alarm "Acknowledge" and the Strobe shall stop at panel "Reset" after normalization of Alarm condition
 - Hooter with Strobe unit shall have provision to be tested by a hand-held field diagnostic tool. The Strobe shall have multiple selectable candela settings configured in the configuration Software / tool.
 - The proposed Hooter cum strobe shall be addressable type. The contractor needs to consider additional modules if the product doesn't have inbuilt addressable option. No additional cost shall be provided by client for providing the additional modules.
 - The rate shall inclusive of all the accessories like backbox, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Addressable Portable Emergency Telephone Handset Jack**
 - Portable emergency telephone handset jacks shall be flush mounted on stainless steel plates as indicated on plans. Handset jacks shall be approved for emergency telephone system application.

- Insertion of a remote handset plug into a jack shall send a signal to the fire command center which shall audibly and visually indicate the on-line condition and shall sound a ring indication in the handset.
- The two-way emergency telephone system shall support thirty-five (35) handsets online without degradation of the signal.
- Remote Telephone Handset shall be capable of making paging announcement across all the zones in the system.
- The contractor shall consider Phone Control module in which directly communicating to the Fire Alarm – Digital Voice Communication panel.
- There will not any additional cost shall be paid for any additional modules (input modules/relay module/control module) shall be required to interface with Fire Alarm – Digital Voice Communication Panel.
- The rate shall inclusive of all the accessories like backbox, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Addressable Fixed Emergency Telephone Handset**
 - The telephone cabinet shall be painted red and clearly labelled emergency telephone. The cabinets shall be located where shown on drawings.
 - The handset cradle shall have a switch connection such that lifting the handset off of the cradle shall send a signal to the fire command center which shall audibly and visually indicate its on-line (off-hook) condition.
 - The two-way emergency telephone system shall support thirty-five (35) handsets online (off hook) without degradation of the signal.
 - Remote Telephone Handset shall be capable of making paging announcement across all the zones in the system.
 - The contractor shall consider Phone Control module in which directly communicating to the Fire Alarm – Digital Voice Communication panel.
 - There will not any additional cost shall be paid for any additional modules (input modules/relay module/control module) shall be required to interface with Fire Alarm – Digital Voice Communication Panel.
 - The rate shall inclusive of all the accessories like backbox, Glands, Screws, Ferrules, Lugs etc. No additional cost shall be provided separately.
- **Batteries Backup for Fire Alarm Panels**
 - The battery shall have sufficient capacity to power the fire alarm system for not less than 48 hours in standby plus 2hours of alarm upon a normal AC power failure. The requirement shall be furnished as per the NFPA 72 latest edition.
 - The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills, and leakage shall not be required.
 - If necessary to meet standby requirements, external battery and charger systems may be used.

1.2.8 Aspiration Detection

- **System Description**
 - Aspiration detection system shall be proposed for “IBMS Server Room”.
 - System consists of highly sensitive laser-based smoke detector using aspirated air sampling & is connected to sampling pipes. It shall be provided with a single/multiple sample pipe inlet, internal flow monitoring, smoke detection & a facility for exhaust pipe connection. Reset, disable, test & fault

determination functions will be available via field service access door. System configuration will be provided through Auto Learn Smoke & flow functions, also available via field service access door.

- It shall support pre-engineered sampling pipe network designs with verified calculations in addition to custom sampling pipe network designs using a computer-based design modelling tool. Sampling pipe material shall be UL 1887 approved for use in air sampling smoke detection systems.
- When required, an optional display unit shall be provided to monitor each detector, & a programmer shall be supplied to configure the system.
- Common hooter cum flasher will be installed in the floor to alert the security personnel in the event when any of the aspiration detectors comes into alarm mode.
- The Aspiration Smoke Detector shall be proposed from the same OEM of Fire Alarm System to facilitate with Seamless integration with Fire Alarm System. The additional Modules to be provided without any cost if the Fire Alarm System OEM product does not have Aspiration Smoke Detector. However, the providing additional modules shall be used to interface with Fire Alarm Panel by taking all the levels of inputs from the Aspiration Detector. Potential Free Contract input / output interfacing with Fire Alarm Panel shall not be approved.
- **Approvals**
 - Aspiration system must be of a type submitted to, tested, approved and/or listed by a Nationally Recognized Testing Laboratory (NRTL) as follows:
 - ✓ UL (Underwriters Laboratories Inc), USA
 - ✓ ULC (Underwriters Laboratories Canada), Canada
 - ✓ FM (Factory Mutual), and FM approved for Hazardous Locations,
 - ✓ LPCB (Loss Prevention Certification Board), UK
 - ✓ Detector shall be installed to comply with following codes or standards:
 - ✓ Fire Industry Association (FIA), code of practice for design, installation, commissioning & maintenance of Aspiring Smoke Detector (ASD) Systems
 - Need to install the aspiration panel at eye level, power supply unit enclosure with the battery back up to be installed just beside or closure to it. Power supply unit needed visible, not accepted in below false floor or above ceiling location.
- **Design Requirements**
 - Shall consist of a highly sensitive LASER-based smoke detector, aspirator, and filter
 - It shall be modular, with each detector optionally monitored by a display featuring LEDs & sounder. System shall be configured by a programmer that is either integral to the system, portable or PC based.
 - System shall allow programming of:
 - Four smoke threshold alarm levels.
 - Time delays.
 - Faults including airflow, detector, power, filter and network as well as an indication of the urgency of the fault.
 - Seven or more configurable relay outputs for remote indication of alarm and fault conditions.

- It shall consist of an air sampling pipe network to transport air to the detection system, supported by calculations from a computer-based design modelling tool.
- System shall be suitable of having a high-level interface with the building fire alarm system.
- **Performance Requirements**
 - Shall be tested & approved to cover up to 250 - 500m² (5,000 sq. ft) based on unit capacity.
 - Shall be approved to provide very early warning smoke detection and provide four output levels corresponding to Alert, Action, Fire 1 & Fire 2. These levels shall be programmable and able to be set at sensitivities ranging from 0.005-20% obs/m (0.0015–6% obs/ft). For compliance to UL approval range is 0.0015-4% obs/ft.
 - Shall report any fault on the unit by using configurable fault relay outputs & via suitable graphic software.
 - Shall be self-monitoring type for filter contamination
 - Shall incorporate a flow sensor in each pipe and provide staged airflow faults.
- **Detector Assembly**
 - Detector assembly in a mounting box shall consist of a highly sensitive laser-based smoke detector, an aspirator & a dual-stage filter cartridge.
 - It shall have control switches for reset, disable, test & restricted access switches for alarm setup & flow setup.
 - Detector shall be LASER-based type and shall have an obscuration sensitivity range of 0.005-20% obs/m (0.0015–6% obs/ft).
 - Detector shall have individual illuminated indicators for:
 - Four alarm levels (Alert, Action, Fire1& Fire 2).
 - Fault (in detector, airflow, filter, system, zones network & power), Power & Disabled.
 - Alarm Setup & Flow Setup.
 - Detector shall have a front-panel, 10 segment, illuminated, coloured smoke dial for the purpose of indicating current smoke level and detector status.
 - It shall have individual relay outputs for Fault, Action and Fire 1.
 - Shall have a built-in provision of BACNet-IP / Modbus - RS-485 / RS-232 compatible serial control port for the purpose of configuration, control, status monitoring, event log extraction & upgrade.
 - Detector shall have an interface card.
 - Detector shall have four in-line sample pipe inlets and must contain a flow sensor for each pipe inlet. Both minor & urgent flow faults can be reported.
 - Filter shall be a two-stage disposable filter cartridge. First stage shall be capable of filtering particles more than 20 microns from the air sample. The second stage shall be ultrafine, removing more than 99% of contaminant particles of 0.3microns or larger, to provide a clean air barrier around the detector's optics to prevent contamination and increase service life.
 - Aspirator shall be a purpose-designed rotary vane air pump. It shall be capable of allowing for single / multiple sampling pipe runs with a transport time per applicable local codes. (Shall be less than 90 seconds)
 - Assembly must contain relays for alarm & fault conditions. Relays shall be software programmable to the required functions. Relays must be rated at 2

AMP at 30 VDC. Remote relays shall be offered as an option and either configured to replicate those on the detector or programmed differently.

- Assembly shall be able to be surface mounted to a wall or recessed in the wall cavity (the unit may be inverted in either option).
- It shall have built-in event and smoke logging. It shall have separate event log storage for smoke levels, alarm conditions, operator actions and faults. Date & time of each event shall be recorded. Each detector (zone) shall be capable of storing up to 18,000 events.
- **Sampling Pipe**
 - Sampling pipe shall be smooth bore. Normally, pipe with an outside diameter (OD) of 25mm and internal diameter (ID) of 21mm should be used.
 - Pipe material should be suitable for the environment in which it is installed preferably approved make CPVC pipes.
 - All joints in the sampling pipe must be airtight and made by using solvent cement, except at entry to the detector.
 - Pipe shall be identified as Air Sampling/Aspirating Smoke Detector Pipe (or similar wording) along its entire length at regular intervals not exceeding the manufacturer's recommendation or that of local codes and standards.
 - All pipes should be supported at not less than 800mm distance interval or that of the local codes or standards. Support stands sample need to take approval from Project in-charge, PMC. It should suit to site requirement & meet aesthetic requirement too.
 - Far end of each trunk or branch pipe shall be fitted with an endcap & made air-tight by using solvent cement. Use of end vent will be dependent on calculations.
- **Sampling Holes**
 - Sampling holes shall not be separated by more than the maximum distance allowed for conventional point detectors as specified in the local codes and standards. Intervals shall be justified by calculations. For NFPA the maximum allowable distance is 30ft.
 - Each sampling point port shall be identified in accordance with Codes or Standards.
 - Consideration shall be given to the manufacturer's recommendations and standards in relation to the number of sampling points and the distance of the sampling points from the ceiling or roof structure and forced ventilation systems.
- **Programmers**
 - Programming shall be performed using a Windows® application running on a PC connected through a High-Level Interfacing unit.
 - Each Programmer shall support the following features at a minimum:
 - Programming of any device
 - Viewing of the status of any device in the system
 - Adjustment of the alarm thresholds of a nominated detector
 - Setting of Day/Night, weekend, and holiday sensitivity threshold settings
 - Initiation of Auto Learn™, to automatically configure the detector's alarm threshold settings to suit the current environment.
 - Multi-level password control
 - Programmable latching or non-latching relay operation

- Programmable energized or de-energized relays
- Programmable high and low flow settings for airflow supervision
- Programmable aspirator speed control
- Programmable maintenance intervals
- Facilities for referencing with time dilution compensation
- Testing of relays assigned to a specific zone to aid commissioning
- **Device Networking Requirements**
 - Devices in the smoke detection system shall be capable of communicating with each other via twisted pair RS485 cable. Network shall be able to support up to 200 devices (detectors, displays and programmers), of which 100 detectors can be supported.
 - Network shall be capable of being configured in a fault tolerant loop for both short circuit and open circuit. Any communication faults shall be reported unambiguously & shall be clearly attributable to an individual device or wire link in the fault messages.
 - PC based configuration tools shall be available to configure and manage the network of detectors. However, Software generated sheet shall be get approved by consultant prior to procure the materials.
- **Initial (Factory Default) Alarm Delay Thresholds**
 - Initial (factory default) settings for the alarm delay threshold shall be:
 - ✓ Alarm Level 1 (Alert) 10 seconds
 - ✓ Alarm Level 2 (Action) 10 seconds
 - ✓ Alarm Level 3 (Fire 1) 10 seconds
 - ✓ Alarm Level 4 (Fire 2) 10 seconds
 - ✓ Fault Alarm 05 seconds
- **Fault Alarms**
 - Detector fault relay shall be connected to appropriate alarm zone on the fire alarm control panel (FACP) in such a way that a detector fault would register a fault condition on the FACP. Minor fault & isolate relays shall also be connected to the appropriate control system.
- **Monitoring Software & Functionality**
 - Software shall support local and remote password-based access control.
 - It shall have a user-friendly graphics user interface.
 - Shall provide support for multiple languages including English,
 - Shall have capacity to monitor multiple connections
 - Shall enable one or more workstations to monitor & configure multiple detection systems in multiple rooms, floors/buildings.
 - It shall provide an event list that provides a single integrated view of all events (faults/troubles and alarms) across multiple sites.
 - Shall prioritize all events presented in the event list according to logical precedence rules.
 - It shall allow management of all events from the event list including acknowledgement of events and resetting of devices.
 - Shall allow colour to be assigned to different event types
 - Software shall allow printing of event lists.
 - Using standard RS485/232 ports or Ethernet on existing & future monitoring & control systems, PCs using the software shall connect to & interpret status

change data transmitted from ports & provide graphic annunciation, control, history logging & reporting as specified herein.

- Network systems that cannot interface to network systems or systems requiring the use of a “dry contact” or “voltage monitoring” interfaces to connect to network systems shall not be accepted.
- Software shall be able to connect to multiple remote sites via IP-based LAN or WAN using virtual serial port emulation.
- It shall be compatible with 4 alarm levels:
- Alert (Alarm Level 1) – may be used to activate a visual & audible alarm in the fire risk area.
- Action (Alarm Level 2) – may be used to alert the security by visual display in the fire alarm panel located at the main lobby.
- Fire 1 (Alarm Level 3) – may be used to activate an alarm condition in fire alarm control panel to call the fire brigade & activate all warning systems.
- Fire 2 (Alarm Level 4) – may be used to activate a suppression system and/or other suitable countermeasures (e.g., evacuation action or shutdown of systems).
- Software shall allow importation of .wav files for event notification.
- Shall support sophisticated floor plan development and management functionality.
- Shall enable floor plan drawings to be used in software to graphically notify users where a smoke event is occurring in their monitored system.
- Software shall allow development of multiple levels of interconnected floor plans.
- Software shall allow importation of AutoCAD, jpg, bmp and other common image files.
- It shall include software to allow designers to create and manipulate CAD images for incorporation in meaningful context-sensitive multi-level floor plans.
- It shall allow for multiple device smoke trending on a single graph.
- Software shall support printing on a printer such as a line printer that supports Unicode.
- The software shall support sophisticated event log management functionality:
- Event logs from all networked detectors shall be able to be retrieved and viewed.
- Event logs shall be able to be archived and stored.
- All system, network and device events shall be stored in an ODBC-compliant database.
- A remote notification facility shall enable the use of email or SMS to provide immediate and up-to-date information the system’s operational status irrespective of location shall be achieved through auto dialer attached to.
- Software shall enable presentation of unique customized corporate response procedures upon occurrence of specific events in defined parts of the facility.
- **Power Supply & Batteries**
 - System shall be powered from a regulated supply of nominally 24V DC. Battery charger & battery shall comply with relevant codes, standards & regulations. Typically, 48 hours standby battery backup is required followed by 30 minutes in an alarm condition.

- Power supply unit enclosure need to mount near to aspiration panel, it should be visible, not accepted it below false floor or above ceiling.
- **Erection & Installation**
 - Detection system: Contractor shall install system in accordance with manufacturer's system design manual.
 - Capillary Sampling Network
 - Where false ceilings are installed, sampling pipe shall be installed above the ceiling & capillary sampling points shall be installed on the ceiling & connected by means of a capillary tube.
 - Typical internal diameter of the capillary tube shall be 5mm or 3/8", maximum length of capillary tube shall be 8m (26 ft) unless manufacturer in consultation with the engineer have specified otherwise.
 - Capillary tube shall terminate at a ceiling sampling point specifically designed and approved by the manufacturer. Performance characteristics of sampling points shall be taken into account during the system design.
 - Air sampling pipe network calculations: Shall be provided by air sampling pipe network modelling program. Pipe network calculations shall be supplied with the proposed pipe layout design to indicate the performance criteria majorly transport time.
- **Document Submittals for Approval**
 - Product data & site drawings shall be submitted & it shall include pipe layout, operational calculations & performance criteria.
 - A copy of manufacturer's installation, operation & maintenance manuals shall be supplied upon completion of installation.
 - System commissioning data shall be supplied (in a format recommended by the manufacturer and per the instructions provided by the manufacturer) within 30 days of completion of the installation.
- **Commissioning Tests**
 - Contractor shall allow for the manufacturer's representative to attend commissioning of the entire installation in the presence of the owner and/or its representative.
 - All necessary instrumentation, equipment, materials, and labour shall be provided by the Contractor.
 - Contractor shall record all tests and system configuration and a copy of these results shall be retained on site in the System Logbook.
- **System Checks**
 - Visually check all pipes to ensure that all joints, fittings, bends, sampling points, etc., comply with the Specification.
 - Check the system to ensure the following features are operational and programmed in accordance with the specification.
 - Alarm threshold levels (for both day & night settings), Pipes in use, Detector address, Display address, Clock and date, Time delays, Air flow fault thresholds, Display buttons operable (Mode, Silence, Reset, Isolate), Referencing Units set to metric etc
 - Check to ensure that all ancillary warning devices operate as specified.
 - Check interconnection with fire alarm control panel, BMS to ensure correct operation.
- **Testing & commissioning**

- Perform the transformer cable burn test as recommended by OEM's, within 120 sec alarms should reach to aspiration panel.
- Verify that transport time from farthest sampling port does not exceed the requirements.
- Activate appropriate fire alarm zones & advise all concerned that the system is fully operational. Fill out the logbook & commissioning report accordingly.
- **Integration with other system**
 - All aspiration detectors shall be integrated with fire alarm panel using interface module (Monitor module) so that fire alarm panel shall monitor & also display the location of aspiration panel.
 - Aspiration panel shall be integrated with BMS through Modbus / BACNet.

1.2.9 Water Leakage Detection System

- **General Requirements**
 - This section covers water leak detection cables, detection modules, control panel & sounders.
 - System is proposed to cover periphery flooring areas of IBMS Server Room to intimate water/liquid presence in critical, highly sensitive areas
 - Water leak detection System shall be integrated with BMS & designed to protect the air-conditioned premises & to alert the personnel about the leak.
 - Events are clearly reported on LCD/LED display with full English language description of the nature of the fault in the panel.
 - Control Panel for water leak can locate inside the same room that is being protected.
- **Main Control Panel**
 - Controller shall have built-in software to sense, receive & recognize the signals sent by sensor cables.
 - Panel shall have 4 x 20 LCD displaying status of all water leakage sensors, door status.
 - System shall be UL listed & manufacture shall be registered @ ISO 9001.
 - In the event of any abnormal condition or malfunction, it activates an alarm that must be acknowledged physically & reset.
 - In-built connectors shall be provided within the panel for interfacing hooters & RS 485 Modbus communication & potential free contacts for FAS integration.
 - Panel shall be connected with UPS for 230 V AC 50Hz & shall be equipped with a 3-pin power supply cord with event logging facility.
 - Accuracy of water sensing shall be at an interval of 0.5 to 1mt.
 - Panel shall also have the feature of software of monitoring & generating reports along with LED display status for all zones.
- **Water Sensing Cable**
 - Water sensing cable shall be resistant to corrosion. It shall detect the presence of water-based liquids but shall not detect hydrocarbons.
 - It shall be reliable to sense any conductive fluid & shall not create any false alarm on application of pressure on the cable.
 - Cables shall be flexible & easy to maintain
- **Accessories**
 - **Jumper Cable Connection**

- ✓ To connect between the sensor module and the sensing cable, jumper cable shall be used for the connections. Warning Labels shall be placed on the sense cable approximately every Three metres. All wire and cable shall be ISI approved.
- **Modular Leader Cable**
 - ✓ Modular Leader cable shall be a minimum 3 metres connection cable with one end prepared for connection to terminals in Control panel / module, and with socket-type plastic connector at other end to connect to the sensor cable / jumper cable.
- **Modular End Termination**
 - ✓ Terminates sensing circuit; has pin-type plastic connector. Required at end of sensing circuit and ends of all branches.
- **Modular Branch Connector**
 - ✓ Allows a “T” or branch in the sensing circuit. Has pin-type plastic connector to connect to cable from alarm module, two socket-type plastic connectors to connect branches. Wires the branches in series and adds a simulated length of 15 ft on each branch to make clear division between areas.
- **Tags**
 - ✓ High-visibility yellow tags to identify sensing cable and record mapped distance. Package contains a permanent marker. Tag attaches to sensing cable by sticking on itself. Use a tag on each length of cable and at mapping points.
- **Hold-down clip**
 - ✓ Hold-down clips to attach sensing cables to flat surfaces. Hold-down clips shall be used to fix the sensing cables for everyone (1) meter or where deem necessary.
- **Panel Security**
 - ✓ The System Monitoring Panel shall provide security to the user or administrator via password access.
- **Power requirement**
 - ✓ The System shall be powered by 230 +/- 15% VAC, 50/60 Hz single phase. It shall be provided with the option to be powered by 12 to 24Vdc or Vac source (if required).
- **Execution**
 - ✓ All System components shall be installed in accordance with the manufacturer's installation instructions, drawings, and local code requirements.
 - ✓ Sensing cable shall be installed after all piping, air conditioning, raised flooring, and other mechanical work has been completed. The sub floor sensing cable path shall remain clear of water, oil, solder, flux, dirt, or other materials that may spoil the sensing cable.
 - ✓ Sensing cable shall be installed beneath the raised flooring, around the perimeter of all rooms, a maximum of three feet from the outside wall. Route the sensing cable a minimum distance of three feet beyond the perimeter of all A/C units.

- ✓ In addition, lay the cable in a serpentine pattern, on 4–8-foot minimum centers, to protect interior surface areas where water sources are found, such as A/C unit, CPU piping, floor drains, chillers, etc. (optional)
- ✓ Cable should be installed under the center of floor tiles to facilitate access to, and visual location of, leaks. Sensing cable shall be secured to the sub floor with plastic hold-down clips) on approximately six-foot intervals.
- ✓ Cable installer shall be responsible for installation of the sensing cable, functional testing, and mapping of the system.
- **Testing**
 - ✓ Upon completion of the system installation, a factory pre-connectorized, five foot long, water-sensing cable shall be temporarily installed at the far end of each leak detection circuit.
 - ✓ Sensing cable shall be immersed in approximately one foot of water, at a depth of 1/8 inch, to confirm that an audible alarm is generated at the alarm module and that the appropriate distance to the leak is displayed. The installer shall perform and certify the tests in the presence of the owner's representative.
 - ✓ A graphic display map, prepared from “as- built” drawings, shall be furnished upon completion. The map shall indicate the location of the sensing cables, landmarks such as equipment, A/C units, walls, floor drains, change of cable direction, and cable distance readings. The map shall be mounted next to the alarm and locating module.

1.2.10 Rodent Repellent System

- **General Requirements**
 - This section covers rodent repellent system with controller, transducers
 - Manufacturer shall have an IDEM & CFTRI certification.
 - Rodent repellent system considered for following areas & all voids (Ceiling Void, Room Void, Floor Void)
 - ✓ UPS Room & Battery Room
 - ✓ IBMS Server Room
 - ✓ ISP & TSP Rooms
 - ✓ HUB Rooms (all floors)
- **Satellite Control Panel**
 - Controller shall support 20 Transducers & shall come with a pair of stands & brackets. The controller is installed in the respective rooms & the transducers in the problematic areas i.e., room voids, below false flooring & above false ceiling.
 - Each controller shall cover 7200 Sq feet of area with 20 transducers covering 300sft coverage each (considering room void areas of 10ft high).
 - Controller shall have LCD display with on-board controls for changing the following parameters like wave speed, wave density, frequency testing, transducer testing.
 - It shall automatically operate at minimum 3 different frequency bands & the time of operation of each band can be set at controller.
 - Controller shall provide 5 different values for the wave speed parameter which is an indicator for the number of frequency sweeps per minute. The 5 wave

speed values shall be 90, 100, 110, 120 and 130/ frequency sweeps per minute.

- It shall have RS/ EIA 485 feature to transfer the controller data to the serial port of IBMS computer up to a kilometre apart.
- Controller shall be password protected.
- Controller shall be equipped with a 3-pin power supply cord of 1.5meters and each controller shall be provided with of 5A electrical plug points.
- Standard 2core, flexible (14/40) SWG multi-stranded CT wires of 275 meters shall be used for connectivity between the transducers and the master console.
- **Transducers**
 - Transducers shall be circular ceiling mounted low profile units that produce high decibel sound waves at very high frequency not less than 20 KHz.
 - These transducers shall cover an area not less than 300 Sq. ft for Room void application, & 200 Sq. ft for ceiling Voids & floor void applications.
 - These shall be powered thru main Controller to 20 satellites in parallel (i.e. no looping of satellites).
 - Transducers shall have pre-tuned operating frequency band of > 20 KHz and <60 KHz.
 - Power output per transducer shall be 800mW.
- **Satellite Control Panel Mounting Stand**
 - Powder coated MS stand accessory for mounting of the master controller.
- **Cables**
 - Standard 2 Core, 0.5 sq.mm, Flexible (14/40) SWG multistranded cable, specially coated CT Wires, for connectivity between the transducers and the master console / as per OEM Standard along with MS conduits.
- **Fire Alarm System & PA System Cables**
 - The wiring shall be PVC insulated 2 core 1.5 Sq mm FRLS shielded copper Conductor stranded cables Outer sheath in red Colour and generally confirming to IS-694-2010 and meet the signal cabling requirements.
 - The strand of cables shall not be cut to accommodate & connect to the terminals. The terminals shall have sufficient cross-sectional area to take all the strands.
- **Field Programming of Fire Alarm System**
 - The system shall be programmable, configurable, and expandable in the field without the need for special tools, laptop computers, or another electronic interface System.
 - There shall be no firmware changes required to field modify the system time, point information, equations, or annunciator programming/information.
 - It shall be possible to program through the standard FACP keyboard all system functions.
- **Electrical Power Supply**
 - Power Supply Source: At-least two independent and reliable power supply shall be provided, one primary and one secondary, each of which shall be of adequate capacity for application.
 - Primary Power Supply: A dedicated branch circuit from power supply source with independent MCB shall be provided near to control panel in form of sockets. The circuit shall be mechanically protected by means of conduit. The

power supply shall provide sufficient power to panel. It shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults.

- Secondary supply: It shall be in the form of storage batteries of sufficient capacity and ratings to operate fire alarm system. The Contractor shall submit necessary calculations for both alarm and supervisory power requirements. The power supply shall be capable of operating the system under quiescent condition (non-alarm condition) for minimum of 24 hours and then shall be capable of operating the system during fire condition for a period of 30 minutes at maximum connected load.
- The battery charger shall charge the system batteries up to 200 AH batteries within 48 hours. Battery charging shall be microprocessor controlled and programmed with a special software package to select charging rates and battery sizes. A thermistor for monitoring battery temperature to control charging rate shall be provided. Transfer from AC to battery power shall be instantaneous (within 10 seconds) when AC voltage drops to a point where it is not sufficient normal operation.
- **Installation of Fire Alarm System**
 - Installation shall be in accordance with the NBC-2016, NFPA 72, local and state codes, as shown on the drawings, and as recommended by the major equipment manufacturer.
 - All conduit, junction boxes, conduit supports, and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage.
 - All fire detection and alarm system devices, control panels and remote annunciators shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas.
 - Manual fire alarm boxes shall be suitable for surface mounting or semi-flush mounting as shown on the plans and shall be installed not less than 42 inches (1067 mm), nor more than 48 inches (122 mm) above the finished floor.
- **Fire Alarm System Cause & Effect (C&E) Matrix**
 - Fire Alarm System Interface with third party Systems at Main Fire alarm Control Panel (FACP) in Fire Control room in Podium1.
 - Necessary wiring, relay, contacts etc. required for interfaces with 3rd party shall be provided by Contractor as per Fire Alarm Cause and Effect (C&E) Matrix.
 - Fire Pump Status: Each fire pump shall have status indication for power failure, pump running status. An audible trouble signal shall sound until acknowledged and automatically restored. The running condition of pump shall be permitted to be alarm condition whereas all other status of pumps shall be permitted to be supervisory condition.
 - The operation of water flow switch shall be permitted to cause an alarm condition at control panel.
 - The operation of Valve supervisory switch and pressure switches shall be permitted to cause supervisory condition at control panel.

- Gas Suppression system activation: On activation of 1st Knock Spot type fire alarm detectors in particular zone/area, there will be LED activation of gas release module in Fire alarm panel.
- On activation of 2nd Knock Spot type fire alarm detectors in the zone/area, Gas release module time delay of 60 secs will start, after which gas to be discharged for the specific zone/room unless Abort is pressed.
- Gas discharge is performed by activation of Zone Gas release valves through Gas release modules.
- Stair Pressurization: Within a given zone, an automatic sprinkler system water flow switch, an open area smoke detector outside a pressurized stairwell shall activate the stair pressurization systems for that zone.
- Access control Door Release: Within a given zone, an automatic sprinkler system water flow switch, spot type detectors activation shall release/deactivate the associated access control door.
- Wiring from Fire alarm Control relay module to Door Access controller shall be done by the Fire alarm Contractor.
- Public address system announcement: Within a given zone, One or Two spot type detectors activation shall activate the announcement of public address system through Control relay modules, as per defined C & E Matrix and with or without delay, as configured.
- In case of fire, Voice Evacuation System to relay evacuation message on specific floor and alert message on two floor above & one floor below immediately as per C&E matrix.
- Emergency Power Status: LED with trouble indicate / ion and buzzer will be activated when the system goes to “emergency” source power.
- Elevator Recall for Fire fighter services at Ground floor: The Ground floor recall shall be activated on alarm by a detector of floor. On activation of detector of floor, all lifts will park at ground floor for further use by Fire fighters.
- FAS system shall interface with Building Management System for monitoring in BMS through BACnet / IP Protocol.

Note:

FAS System needs to be configured as per Client initial requirements during the project stage. However, the vendor may have to modify the configurations & settings in future for improvements & based on customer requirements for various floors. Vendor should not charge additional for any such modifications & changes in Fire Logics / C & E Matrix etc. Vendor needs to ensure availability of the backup of all the FAS Panels / Logics / Configurations etc. In the BMS System desktops & provide backup copy on external media like CD / USB Drive. System shall be programmed as per the approved cause & effect logic.

- **Execution at Site**

- **Preparation of documents**

- ✓ Carefully check Drawings and specifications of other trades before installing any work. In all cases consider the work of all other trades, and coordinate this work with that of the structural, sheet metal, piping, plumbing, electrical, and site work Contractors so that the best arrangement of all equipment, piping, conduit, ducts, and other related items can be obtained.

- ✓ Coordinate work to the end that there is no conflict between location of detectors and electric fixtures, piping, ducts, and other items
 - ✓ Call to the attention of the Client any points of conflict between fire protection work and that of the other trades, so that the conflict may be properly resolved. Work which interferes with the work of other trades shall be removed and re-installed at Contractor's expense when so directed by the Client.
 - ✓ It is the Contractor's responsibility to provide additional work as necessary to satisfy the requirements. It shall be understood that no extras to the Contract will be permitted to accomplish the above results
 - ✓ The Contractor shall take any necessary measures to prevent damage to the facilities and equipment and shall take any necessary measures to keep the premises always dry. Damage resulting from the work and testing under this section, whether intentional or not, shall be repaired by the Contractor at no cost to the Client.
- **Installation at site**
- ✓ All equipment shall be installed in an aesthetic and skilled manner in accordance with applicable codes and other applicable standards referenced by this document. Final appearance of all systems and equipment shall be neat and clean. All piping in areas with finished ceilings shall be concealed.
 - ✓ Refer to the Drawings for mounting heights of wall-mounted visual signaling devices, unless otherwise required by local governing authorities.
 - ✓ All wiring for the System shall be in accordance with applicable Standards.
 - ✓ All splices shall be made using solderless connectors. All connectors shall be installed in conformance with the Manufacturer recommendations.
 - ✓ Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.
 - ✓ Permanently label or mark each conductor at both ends with permanent alphanumeric wire markers.
 - ✓ The Contractor shall submit for review prior to installation of wire, a proposed colour code for system conductors to allow rapid identification of circuit types.
 - ✓ Wiring shall be checked and tested by the Contractor in accordance with the instructions provided by the Manufacturer to assure that the system is free of earths, opens, and shorts.
- **Inspection and Testing**
- ✓ The system shall be subject to inspection and acceptance by the Client in accordance with applicable standards.
 - ✓ Authorities Having Jurisdiction for the purpose of determining the system is in accordance with life safety requirements federal, state, local and specification requirements only and not the adequacy of the design for asset protection.
 - ✓ The Contractor shall be responsible for performing and certifying requisite inspection and tests in accordance with applicable codes and standards for all equipment furnished under this specification.

- ✓ Inspection and test procedures shall be submitted to the Engineer for approval prior to use.
- ✓ All field tests performed by the Contractor shall be conducted in the presence of the Client and other representatives. All persons concerned shall be notified two weeks in advance of the tests to arrange attendance at the tests.

1.3 Digital Public Address System

1.3.1 System Design Requirements

- The voice alarm system shall be the integrated solution for BGM and EVAC. The voice alarm system shall be designed for public address and emergency evacuation. All the essential EVAC functionality – such as system loudspeaker, digital message management and a fireman's panel interface – shall be combined.
- The system shall provide for emergency call (EMG), business call and BGM audio, up to 120 zones, 32 call stations. The voice alarm system shall be a Single channel system. It shall be compatible with BGM sources and 100 V booster amplifiers. It shall be capable of connecting to EVAC compliant loudspeakers and accessories for an integrated public address and voice alarm solution.
- Volume override relay contacts shall be provided for each zone separately for overriding local loudspeaker volume controls. All current override schemes shall be supported (3-wire and 4-wire override schemes i.e. standard 24V and failsafe). Upon a call or an activated trigger input these contacts shall be activated for the appropriate zones, together with an additional voltage free contact (Call Active) for control purposes.
- A 24Vdc output shall be available to supply power to external relays, so no external power supply shall be required for that purpose.
- The maximum allowed total cable length between the controller and the last call station in the chain shall be 600 meters
- Simple plug & play features are available by default setting of the system which do not require any configuration to meet basic requirement for single buildings.

1.3.2 Digital Integrated System Manager / Controller

- The voice evacuation system controller is public address & voice evacuation system. The all-in-one voice alarm & evacuation controller built-in remote PC software, zone paging controller, all main signal line monitoring, amplifier changeover, speaker line supervision, power supply monitoring and power amplifier, voice recorder, SD card, emergency microphone and fire alarm interface.
- The voice evacuation controller is innovated with DSP (digital signal processor) to ensure its hi-fi audio performance and superior signal processing in case of commercial announcement and emergency evacuation.
- Each controller built-in 8 zone speaker outputs, rated power output at 500W.
- The voice evacuation controller shall be pre-set through the supplied software over microphone number, zone number, zone loading, speaker monitoring, fire alarm mode, alert/EVAC message zone output, AC/DC etc, then synchronized the setting to master controller and router.
- **Technical Specifications:**
 - Digital voice evacuation system all in one solution.

- Integration of voice evacuation controller, remote PC software, zone paging controller, all main signal line monitoring, amplifier changeover, speaker line supervision, power supply monitoring and power amplifier, voice recorder, SD card, emergency microphone and fire alarm interface.
- Auto broadcasting EVAC and alert 256 voice messages to pre-set zones.
- Customized alert, evacuation & business message stored at SD card.
- AB speaker line surveillance to avoid any speaker line failure.
- Back-up power amplifier management.
- Up to 120 zones by cascaded more router.
- Support 32 units of remote paging microphone.
- Support external connection of fireman microphone.
- Redundant network cabling backup through CAT6 cable loop connection.
- 8 supervised control inputs & 8 control outputs, 1 fault, 1 reset & 1 EVAC relay outs.
- Logs and fault events auto recording.
- **Technical Features of Slave Controller / Router**
 - The Slave Voice evacuation system controller is public address & voice evacuation system.
 - Each slave controller built-in 8 zone speaker outputs, rated power output at 500W.
 - The voice evacuation controller shall be pre-set through the supplied software over microphone number, zone number, zone loading, speaker monitoring, fire alarm mode, alert/EVAC message zone output, AC/DC etc, then synchronized the setting to master controller and router.
- The following functional requirement shall be available in the Digital Integrated System Manager / Controller and Slave Controller / Zone Expander / Router
 - AC Power Indicator: Green - means currently host AC supply normal. & Yellow - means currently host AC supply failed.
 - 24V DC Indicator: Green - means current host 24V DC standby power supply is normal, Extinguish - means Current host has no 24V DC backup power supply & Yellow - means current host 24V DC backup power failure.
 - Communication Indicator between Host and Extension Host: Yellow - means no logical or physical connection between host and extension host, Extinguish - means no logical or physical connection between host & Green - currently means device connection is normal.
 - Fault Indicator: Off means system working well unless the dipswitch PIN of all supervision function is disable on rear panel & Yellow means system fault, otherwise, press "ACK/REST" to restore the system.
 - Emergency Microphone Indicator: Yellow - means emergency microphone lost or faulty, Green - means working well & Extinguish - means microphone is normal but it is not working.
 - Indication Test Button: Press the button to light on the LED indicators of all equipment's include host, extension, and paging microphone to test the indication working well.
 - Emergency Button.
 - ✓ Red flash—emergency mode.
 - ✓ Extinguish--normal mode.
 - ✓ Making Emergency Broadcast

- ❖ Emergency broadcast will be activated by manual press the button and red-light flashing.
- ❖ Auto emergency broadcast will be activated by the trigger inputs on the rear panel of host and extension unit and red-light flashing.
- ✓ Reset the Emergency Mode:
 - ❖ Press the “ACK/Reset” button on the front panel to exist the emergency mode to terminate the emergency broadcast and terminate the zone output.
 - ❖ Input a reset signal to the emergency control input terminal on the rear panel which has been assigned a reset function. These events history could be recorded and inquired in the software history record.
- ACK/RESET Button
 - ✓ If the system various modules work normal or abnormal system module diagnosis but press the button when the indicator "FAULT" light is not flashing, equipment do not do any processing,
 - ✓ If the system module in the diagnosis of abnormal, "FAULT" of FAULT indicator light flashing, press some button, "FAULT" stopped lighting from blinking, blinking indicating its disabled state, Buzzer to stop till To the new module detects abnormal after heavy shine again "FAULT" LED lamp and start the buzzer hint user,
 - ✓ When the current partition has output, press the build close the current audio output, quick exit and quit play.
- EVAC MSG & ALERT MSG
 - ✓ Green - “EVAC MSG/ALERT MSG” Voice is in broadcast information
 - ✓ Yellow – “EVAC MSG/ALERT MSG” Lose voice information or loss SD card
 - ✓ Extinguish—— “EVAC MSG/ALERT MSG” Normal.
 - ❖ "EVAC voice information" refers to the EVAC voice ALERT and voice.
 - ❖ If you need to manually play EVAC voice messages, Need to enter the emergency mode, Then press the voice messages button.
 - ❖ System default “EVAC” Voice priority is higher than "ALERT". Can change the priority through the configuration. If not special application requirements, please do not change it.
- Line Input Selector: Mainly used to select the external line input to this host or extension.
- All Zones: To select all six zone outputs open or close at the same time.
- Zone Fault Indicator: Yellow - The current partition A and B or A or B speaker impedance change, may be open or short circuit and Extinguish - The current speaker zone loop impedance changes within the impedance of the speaker when it was pre-set.
- Paging Indicator: When paging, can manually close the zones where no need paging or add new zones.
- EVAC/ALERT Indicator: When EVAC and alert emergency broadcast is working, the indicator will be light on.
- BGM Indicator: When background music broadcast is working, the indicator will be light on
- Zone Selector: To select individual six zone output open or close.

- Zone Output Attenuator: Increase or decrease the individual zone speaker output loudness at 6 levels and max control of -15dB.
- Emergency Microphone Input: Input for the emergency microphone or fireman microphone of priority.
- Monitor Speaker Attenuator: Increase or decrease the built-in monitor speaker loudness.
- Emergency Microphone Gain Control: It is used to adjust the emergency microphone input sensitivity.
- Treble Control: Increase or decrease the overall treble output.

1.3.3 Dual Channel Class – D Power Amplifier

- **Technical Descriptions:**

- The amplifier shall provide 70/100V loudspeaker output voltages that are galvanically separated.
- The amplifier shall have 2 x 100V audio input to support remote audio transmission.
- System control and audio shall be transmitted via RJ45 connectors.
- The Amplifier shall have inbuilt Dual Channel Speaker Circuit / Zone Circuit as mentioned below
 - ❖ 2 x 500W Amplifier – Total 1000W
 - ❖ 2 x 240W Amplifier – Total 480W
- The Amplifier shall be an CE compliant
- The Amplifier shall be put in a 2U, mountable at 19" Rack Cabinet.

- **Technical features:**

- Class-D technology with high efficiency.
- Maximum 500W power output.
- 100V/70V selectable output.
- Supports both balanced and unbalanced audio input.
- Forced fan cooling.

1.3.4 Call Station/ Paging Console

- **Technical Descriptions:**

- The remote microphone or call station is designed exclusively for controller to use for public address & voice evacuation system.
- The remote microphone is used for business and commercial live announcement to selected zones or all zones.
- The remote microphone is designed of 12 zone buttons with busy & working indicators.
- One or multiple external 12 zone expansion keypad could be cascaded together for up to 120 zone operation.
- Up to 32 units of remote microphone could be connected to the voice evacuation system via standard, shielded CAT-6 cable and RJ45 connectors in a redundancy loop up to 600 meters.
- The talk button maybe a PTT or lock type pre-set by the dipswitch on the rear of the microphone.
- Green LED indicates the microphone and zone active status. The remote microphone is 24VDC powered by the controller.

- **Technical features:**

- Remote microphone or call station of voice evacuation system .
- fireman's microphone.
- Business & commercial zone live announcement use.
- Multiple zones, single zone & all zone paging.
- Each microphone of 12 zone capacity.
- Up to 120 zones by cascaded the zone keypad.
- Support 32 remote microphones of loop redundancy connection.
- The remote microphone unit is fully real time monitored.
- Support PPT and lock type two modes.
- Shielded CAT-6 cable up to 600 meters.
- Power supply from controller

- **Technical Specifications:**

Description	Features
Description	Remote Paging Microphone
System Capacity	32 units
Communication Distance	600 meters
System Connection	Star connection or loop redundancy connection
Zone Number	12 zones or 12 groups
Paging Mode	PPT & normal paging modes
Electrical Part Phantom Power Voltage	20V-27.5V
Max Current	<0.1A
Power Consumption	<2.4W
Line Input Sensitivity	775mV
Impedance	10kΩ
S/N Ratio	>70dB
Microphone Input Sensitivity	5mV
Impedance	600Ω

1.3.5 Loudspeakers

- **6W Ceiling Loudspeaker**

- The lower ceiling areas shall be supplied with Recessed Ceiling loudspeakers with optional metal fire dome.
- The Loudspeaker shall be suitable for delivering audio in the full frequency band. The loudspeaker shall be humid resistant.
- The speaker is made up of powder-coated metal housing for Voice Alarm applications.
- The ceiling loudspeakers shall be rated for 6 watts output power, with an integrated 100V line matching Transformer with multiple taps.
- The speaker shall be equipped with neodymium magnet.
- The ceiling mount shall be Bayonet recessed with low installation depth.
- Spring-loaded snap locks with cranked leg spring, increased clamping strength and shorter tension interval ensure quick and simple mounting.
- The ceiling loudspeaker shall be equipped for the following performance criteria.

Parameters	Values

Rated power	6 W
Power taps @ 100V	6W / 3W / 1.5W
Sound pressure level at 6W/1W (4kHz, 1m)	94dB / 86 dB
Frequency range (-10dB)	57 Hz -24 kHz
Dispersion angle (1kHz/-6dB)	180°
Rated input voltage	100 V
Connection	Plastic terminal blocks
Dimensions (Φ x H)	Φ181 mm x 66 mm
Hole cut-out size	Needs to be specified by OEM
Size of speaker	5 to 6" Max
Color	White (RAL 9016)
Material	ABS Housing & Metallic grille

Note: The rate shall inclusive of all the necessary accessories like M.S Backbox (for True Ceiling Speakers), Gland, Screws, Ferruling, Lugs etc. However, the speakers shall comply with EN Standards. Hence, the fire dome cabinet shall be considered without any additional cost of each Speakers.

- **6W Wall Mounted Cabinet Loudspeaker**

- The non-false ceiling services Room areas shall be supplied with Wall mounted loudspeakers with metal fire dome.
- The Loudspeaker shall be suitable for delivering audio in the full frequency band. The loudspeaker shall be humid resistant.
- The speaker is made up of powder-coated metal housing for Voice Alarm applications.
- The wall mounted loudspeakers shall be rated for 6 watts output power, with an integrated 100V line matching Transformer with multiple taps.
- The speaker shall be equipped with neodymium magnet.
- The ceiling loudspeaker shall be equipped for the following performance criteria.

Parameters	Values
Rated power	6 W
Power taps @ 100V	6W / 3W / 1.5W
Sound pressure level at 6W/1W (4kHz, 1m)	94dB / 90 dB
Frequency range (-10dB)	57 Hz -24 kHz
Dispersion angle (1kHz/-6dB)	180°
Rated input voltage	100 V
Connection	Plastic terminal blocks
Dimensions (Φ x H)	As per OEM standard with minimum space occupancy.
Size of speaker	Compact Square / Rectangular Speakers to be proposed.
Color	White (RAL 9016)
Material	ABS Housing & Metallic grille

Note: The rate shall inclusive of all the necessary accessories Gland, Screws, Ferruling, Lugs etc. However, the speakers shall comply with EN Standards.

- **15W Wall/Surface Mount Cabinet speaker**

- Surface mounted loudspeakers shall be provided for surface mount in areas without false ceiling.
- Two-way compact speaker, power of 15 W RMS at 100 V line, also with connection available at 8 ohms. It can be installed on the wall or ceiling with the swivel bracket included, both indoors and outdoors (it has IP65 degree of protection).
- The speakers shall be available in black and white. The Client / Consultant will choose the colour of the speakers post tender awarded to successful bidder.
- The speaker shall be equipped with line matching transformer suitable for 100 V line.
- The Loudspeaker shall be weather-proof and suitable for outdoor use.
- The cabinet loudspeaker shall be equipped for the following performance criteria.

Parameters	Values
Rated power	22 W
Power taps @ 100V	15 W/7.5W/3.75 W/1.8 W
Sound pressure level at 6W/1W (1kHz,1m)	94 dB / 82 dB
Frequency range (-10dB)	82 Hz -23.5 kHz
Opening angle	186° (H), 186° (V)(1Khz)
Color	Black/ White
Rating	IP65 Rating
Dimensions (W x H x D)	210 x 130 x 120 mm
Material	ABS, metallic grille

Note: The rate shall inclusive of all the necessary accessories Gland, Screws, Ferruling, Lugs etc. However, the speakers shall comply with EN Standards.

1.3.6 Volume Controllers

- Volume Controllers have the following four types: 6W & 30W respectively. The features are as follows:
- Build-in 24V DC forced cut-off relay
- 5 volume levels control
- Applicable to 3-wire, 4-wire and 6-wire systems
- Standard 86X86 installation base-shell.

Parameters	Values
Rated power	30W Max
Supply voltage	100V
Frequency response	50Hz~20KHz
Attenuation	5X2dB + off
Current consumption	20mA, 24V DC

1.3.7 Cables & Wiring

- All the cables, conduits & cable tray shall be proposed as per the details provided under Fire Alarm System. However, the cable outer sheath shall be considered in Blue / Grey colour.
- However, the outer sheath colour shall be finalised at the procurement.

Note: The OEM shall have an option to re-engineer the Quantity of each equipment without damaging the technical requirement, design changes, BoQ description, individual item price, with respect to the make selection. However, the same shall be done post the order awarded to the contractor. This assignment shall be carried out with proper analysis/site inspection with backup documents. If any cost shall not be bring-down the contractor needs to go-ahead as per the original design approached herewith.

1.4 Security Access Control System

1.4.1 General Requirement

- The ACS must fulfil all the Access Control Operational Requirements, it is the responsibility of the bidder to ensure the required technology, integrations and workflows are provided by ACS with no deviation.
- The ACS shall be an enterprise-class service-oriented solution platform providing a comprehensive solution to the physical security and identification application needs as follows:
 - Access Control
 - Time Attendance
 - Centralized Alarm Management
 - Emergency & Evacuation Management
- The Access Control System Software shall have an inbuilt feature as mentioned below
 - Security Access Control Module
 - Vehicle Access Control Module
 - Attendance & Time Management Module (HRMS)
 - Video System Interface (CCTV) Module

Note: All the above features shall be provided as a part of Access control System Software Cost. However, the IBMS integration shall be done through Software & Hardware level without adding any additional third-party devices.

- The ACS system must support a unified database upgrade approach, utilizing a single upgrade patch that seamlessly upgrades from any lower versions. Manual execution of multiple version patches for database upgrades will not be accepted. The upgrade process should be streamlined and automated for efficiency.
- The ACS shall be based on a true open architecture which means that the platform shall have the ability to integrate with several third-party open architecture intelligent devices and technologies such as:
 - Access Controllers & Card Readers
 - Biometric Readers & Enrolment Devices
 - QR Code Readers
 - Card Printers
 - Card Encoding Devices
 - Smart Cards, Mobile/Digital Credentials
 - BLE/NFC-based access readers.
- The ACS shall have the flexibility to switch to a different access control software without the need to replace the hardware or part of the hardware. The ACS software license shall be fully perpetual and free from any hardware locking like dongles.

- The ACS software license shall provide unlimited user logins, unlimited client licenses for system monitoring and configuration tools, and unlimited branches and shall be further scalable for up to thousands of controllers.
- It shall also be ensured that the software OEM shall not discontinue the proposed software for at least 5 years and the support shall be available for at least 8 years.
- The ACS shall be open to interface with other security & and safety systems like CCTV Video Surveillance System, Fire Alarm System, Intrusion Management System, and Building Management System (BMS). The ACS system shall be open to be customized and integrated with any other third-party system as per the user requirements.
- The ACS shall support bi-directional integration with Information Technology (IT) Systems like Enterprise Resource Planning (ERP) System, Human Resource Management (HRM) System, Student Information System (SIS) and Customer Relationship Management (CRM) System via APIs. This integration shall provide Employee profile synchronization/transfer from the IT system to ACS Software and Attendance log transfer from ACS Software to IT System. The APIs shall be readily available and shall be provided along with the ACS software.
- The ACS software shall be a multi-user design where a logged-on user in the software whether on the web interface or on the client interface shall not have any effect on the user experience or operational capabilities of any other user logged on to the software. Also, the changes made by one user shall be updated for other users on a real-time basis.
- The ACS software shall provide options to create multiple branches. It shall further allow to creation of the enterprise structure by creating the branch hierarchies.
- The ACS software shall allow the system administrator to create a complete organizational structure by defining multiple departments, designations, and Employee types. The users shall be created and shall be mapped with their corresponding department along with the related designation. There shall be no limit on the creation of departments, designations, and Employee types. This shall allow for the creation of a complete hierarchical chart by allowing each user to be mapped with their reporting manager and selecting the profile of the superior.
- The ACS software shall provide a tool for defining user privilege templates in the software. The software shall have default templates like Administrator, Group User, Normal User, etc. These templates can be used as the base templates to further create unlimited new privileges by enabling or disabling any function or feature of the software. All the users of the software shall have access to the software based on the privilege assigned to them.
- The ACS system shall provide a comprehensive login and password policy which shall be configurable by the end user in terms of the following parameters as minimum:
 - Password parameters like minimum and maximum length, use of alphabets as mandatory or not, use of upper case as mandatory or not, use of lower case as mandatory or not, use of numeric as mandatory or not, and use of special characters as mandatory or not.
 - Passwords Generation Policy: Auto-generate password on account creation, enforce password change on 1st login, Privileged user can reset others password, enable, or disable 'Forget Password' feature, generated reset password link expires in a day(s)

- Notifications: Notify user on account creation, notify the user on admin reset password
- Password Expiry Policy shall allow to select either none or to define the number of days after which the passwords automatically expire.
- Login Parameters: Using Employee ID as username, using email ID as username, enable or disable login lockout, define several unsuccessful attempts before lockout & and lockout time in hours.
- The ACS software shall be language agnostic and provide a methodology to create labels in all local languages used worldwide. These labels can be uploaded back to the software and can be saved in the language section as the user's personalized choice of language and dialects. Once saved the users shall be able to switch between the saved languages.
- The ACS software shall provide an option of personalizing the portal by users by changing the Colour theme of the software. It shall also provide the option of setting custom Colours by defining Colour codes for the menu background colour, menu mouse hover Colour & menu text Colour. The software personalization option shall also enable users to upload their corporate logo to be used on each page of the software.
- The ACS software shall also provide dashboards for users to choose widgets to be shown on their dashboard. It shall allow creating a new dashboard by simply defining the name and making it active. Further, it shall be possible to select different default widgets to be shown on each dashboard template and it shall be possible to make these widgets available to multiple privilege levels defined for the software. The minimum available widgets shall be:
 - Alarm Count Weekly
 - Branch Attendance Summary
 - Card Summary
 - Dormant Cards
 - Employee & Visitor Head Count
 - Employee & Visitor In-Out Count
 - Security Behavioural Anomalies and Incidents
 - It shall also be possible to export these widgets to another portal by providing a link to a specific widget which can be embedded by any other portal like ERP system, HRMS, website, etc.
- The ACS software shall be cloud-ready, so if the system stakeholders decide to install it over the cloud, then it shall be possible without additional licensing. The licenses shall be valid for hosting it on-premises server or the cloud.

1.4.2 Functional Requirements

- The ACS software shall provide menu-driven functions for ease of use and best user experience. The following modules shall be part of ACS Software:
 - User Management
 - Credential Management
 - Access Control
 - Time Attendance Module
 - Visitor Management Module
 - Badge Printing Module
 - Hardware Configuration Module

- Alarm Monitoring and Management Module
- **User Management Module**
 - The User Management Module of ACS Software shall support the following:
 - ✓ Seamless active directory integration for single sign-on, automatic import of Employee details, and automatic deactivation of access rights on Employee profile deactivation in the active directory server
 - ✓ Adding users with standard fields like name, email, Employee id, contact details, blood group etc. and option shall be available to create at-least 40 additional custom fields.
 - ✓ Adding Employee photograph along with provision to add at-least three more pictures corresponding to an Employee such as scanned copies of national ID card, passport, police verification etc.
 - ✓ Managing access rules in terms of setting up extended access time for physically challenged users, pass back exemption for specific users, PIN exemption for specific users and Multi Man Role.
 - ✓ Assigning up to 8 access levels per user, an additional 2 elevator/lift access levels and unlimited shared access levels. The users shall get access to the different areas of the premises based on these access levels. It shall be possible to group users and assign them the access levels in bulk.
 - ✓ Assigning current and future shift roster to an Employee. It shall be possible to assign Shift roster to Employees in bulk.
 - ✓ Defining custom Employee groups. The feature shall facilitate the logical grouping of Employees based on management structure, thus shall empower the project coordinators, floor-managers, or project managers to manage access rules and view reports of a specific user- group. It shall be possible to delete these groups.
 - ✓ Assigning privilege level of an Employee like Administrator for the entire system, administrator for a branch only, report viewer and a normal user having access to own personal information/ personal reports/ability to file outstation duty request, visitor request as minimum. It shall be possible to create group users to manage access of groups.
 - ✓ Assigning a privilege to approve visitor request and outstation duty request. Assigning privilege of a security administrator who can configure and monitor the access control hardware and a security viewer privilege who can only monitor and respond to the event and alarms.
 - ✓ It shall also be possible to select 'None' as a privilege which allows no access to the software.
 - ✓ Advanced search form to search users on fixed and mixed search criteria such as: name, department, title, access group, credential status etc.
 - ✓ Assigning access levels to an Employee of the same organization visiting a different branch.
 - ✓ Assigning Mobile App and Mobile credentials to users. This shall also allow to edit the mobile privilege of a user, remove the mobile privilege of a user, and delete a mobile device from the user-authorized list of devices.
 - ✓ Importing the Employee or contractor profile information from Excel/CSV file.

- ✓ The application must have the option to generate secure auto passwords instead of default passwords.
- ✓ The application shall have the ability to create a custom field with unique attributes. If marked as unique, the field's value must be distinct across the entire company. Additionally, the user can set a custom field as compulsory, ensuring that an employee profile cannot be added or edited without providing this value. Furthermore, dropdown-type custom fields allow users to define multiple options for the field, including a default value.
- ✓ The application allows defining a unique PIN to trigger specific command events on pin pad readers. Users should be able to create Input/Output rules linked to this transaction, enabling enhanced control and automation. For example, entering a preset PIN could trigger a premises lockdown or activate a specific output, like turning off all lights, providing convenient and customizable access management.
- **Credential Management Module**
 - The credential management module shall provide the following functionalities:
 - ✓ Create and maintain credential directory. It shall be possible to upload all card details (format and/ or card ID) in the ACS Software and whenever required it can be issued to the Employee. The card IDs which are not issued to any users shall be made available by the software to be issued to Employee.
 - ✓ Searching of cards based on various searching criteria drop downs such as Employee ID, Employee Name, Card Number, Format Name, Status (active/inactive). It shall also be possible to search the mobile ids/credentials issued to different users using the search tool.
 - ✓ Issuing a credential where the credential can be issued to either a human or vehicle, access type shall be selectable from different modes, 'card only', 'card + pin', 'card or pin' and 'pin only'. It shall also be possible to issue card/credentials from the list of available credentials or manually adding a card id.
 - ✓ Editing a credential where cards can be searched either by Employee Id or Card Number and allows the user to edit PIN, Card Issue Date, Card Type and Expiry Date. It shall also allow us to set the status of a card to active or inactive.
 - ✓ Segregate credentials into different categories based on owner types such as Employee, vehicle, visitor etc.
 - ✓ Assigning credentials to Employee in bulk and assigning multiple credentials to single user.
 - ✓ Capable of managing multifactor authentication for biometric readers also like finger only, finger + card, card only, finger or card etc.
 - ✓ Searching interface to edit the credentials or to get the complete visibility of the company owned credentials along with their status.
 - ✓ Assigning priority or VIP category to a card id or to a user so that the credential is never denied access on the ACS System.
- **Badge Designing, Printing & Encoding**
 - The ACS Software shall also be capable of designing Identity Badges for the users and it shall be possible to print & program these cards using open

platform card printers & Encoders. This functionality shall support windows-based image printing command so that the designed badges can be printed from a variety of card printers. The following options shall be available in the application.

- ✓ Select or define the size of the ID card/Badge.
- ✓ Pick & Drop user information from the available list of profile information fields like name, department, designation etc.
- ✓ Uploading the Photo or Automatically fetching the photo of a user from the database.
- ✓ Uploading corporate logo as opaque or as a background image
- ✓ Alignment shall be possible for all fields.
- ✓ Save the ID card/ Badge template in the software for printing.
- ✓ Application shall support card key management by encoding multiapplication smartcards like Mifare and Desfire cards with a USB encoder. It must comply with the requirements for fast and highly secure data transmission, flexible memory organization and interoperability with existing infrastructure.
- ✓ All the above functions will be available for Employee as well as contract labours Via Integration to contract labour management system.
- ✓ The badging system shall support printing of custom fields apart from standard fields available in access control application.
- ✓ The system shall be capable of encoding cards to save biometric templates on its memory of the card. This is used to open biometric doors where biometric templates are not saved on the device.
- Following options shall be available for ID Card/Badge Printing:
 - ✓ Automatic fetching the user profile information according to the saved template of badges.
 - ✓ Automatically managing static & variable data printing.
 - ✓ Single or Dual side printing.
 - ✓ UV codes to make ID Cards easier to identify and printing them in compatible printers.
- **Biometric Enrolment and Distribution**
 - The ACS Software shall be integrated with different biometric technologies which are fingerprint, face recognition, Iris, 3D Fingerprint (Wave). The Enrolment module shall support enrolment of all these technologies from a single software interface.
 - The ACS Software shall be integrated with different biometric manufacturer's directly with the devices, it shall not use any middleware software or database from the manufacturer, for enrolment of the biometric templates of the users.
 - The ACS Software shall be integrated in such a way that it shall not use any middleware software or database from the manufacturer, for communication and distribution of the biometric templates of the users to all the biometric devices.
 - The ACS software shall enable enrolment directly from the Biometric device over TCP/IP or from the USB based enrolment setup. It shall have no effect on the distribution, which shall happen to all devices.
 - All above functions shall be available for Employees as well as contract labours.

- **Hardware Configurations Module**

- The hardware configuration module should list all controllers configured in the application with details such as Name, MAC address, IP Address, Make, Type.
- It shall be possible to search hardware from the network with the help of 'search device' tool and it shall contact search capability by taking inputs like MAC address or make of the hardware.
- The Hardware config must be able to add any new controller or biometric device by filling details of the hardware like Make, Type, Name, MAC Address, IP Address, ID.
- Hardware configuration shall allow users to group multiple controllers with features such as 'action group details' it should be possible to make multiple groups of controllers.
- This tool shall allow configuring and creating different floor names with details such as ID floor name etc, which will be further used on the Elevator access management.
- This module should have various options to troubleshoot connected hardware. It must be able to reset controller, reset SIO, reset time, sync time zone, sync access group, sync card format, sync card DB, sync IO mapping, reset access areas, enable event reporting, disable event reporting, reboot controller, and factory reset.
- Hardware configuration tool should allow users to rename controllers and configure Interface devices.
- This module should allow users to configure readers which are connected to the application and should be able to name the readers and configure parameters such as reader protocol, reader address, reader type In/Out, Access type, Access grant time for the door, minimum open time for lock, REX in, Door held time, OSDP secure channel, Advanced control, PL Bypass, OSDP Baud rate to have the door and reader definitions mapped on the application.
- The hardware config tool should be able to list all the inputs configured on the platform with relevant information such as Input name, Interface type, Input port, controller name, MAC Address, Controller type, Last updated on, Updated by (user).
- The hardware config tool should be able to list all the readers configured on the application platform with details such as name, position, type, interface type connected to, controller connected to, MAC address, controller type, protocol, updated on, updated by (user).
- The hardware config tool should be able to list all the configured on the application with details such as, Output name, output port, interface type, controller name, MAC address, controller type, last updated on, updated by (user).
- Users must be able to blacklist a controller/device. Upon reconnection of a blacklisted controller/device, the device shall undergo a factory reset for security reasons. This feature is crucial to ensure the application's security by preventing unauthorized or compromised devices from accessing the system. The factory reset will eliminate any potentially harmful configurations or data on the blacklisted controller/device, bolstering the overall security and integrity of the application and its connected components.

- **Logical Area control**

- The Application shall allow users to configure physical areas with entry and exit to map logic to the specific area and drive policy and features around this configuration.
 - ✓ An area configuration must have information like ID, Name, Alias
 - ✓ Area mapping configuration must cover information such as name of reader, type of reader, Area IN drop-down, Area out drop-down.
 - ✓ This tool must allow user to configure 'who's where' tool with ability to include or exclude details such as User ID, username, current area, time entering the current area, department, designation, mobile number, office phone. This allows a person trying to people to have access to vital information.
 - ✓ This tool shall allow user to user to group areas in groups for various purposes.

- **Access Control Module**

- The ACS Module shall provide options to configure multiple access levels. The Access Level shall be a combination of various access parameters such as working day/holiday, time codes, reader groups, elevator groups, etc.
- The ACS Module shall support assigning access levels (up to 8 access levels per facility/branch/business unit) to a set of users to enable them to access specified areas & additional 2 access levels for elevators during a specified period.
- The ACS Module shall support multi-Man role enforcing more than one user to present their cards to get access through the designated access-controlled points.
- The ACS Module shall support Timed Anti-pass-back (APB) which means it shall be possible to define a time delay between 2 readings of a same access card. This shall enable to avoid unwanted events logged in the system and within the defined time, it shall avoid reading the same card if passed back by its user to another person.
- The ACS Module shall support Soft APB and Hard APB, where Soft APB shall generate an alarm in the Module if a user has any miss punch on any of the entry or exit reader of a door but shall not deny access, the Hard APB shall generate Module alarm if a user has any miss punch on any of the entry or exit readers & additionally the controller shall deny access for the same user on the door.
- The ACS Module shall support Local Anti-pass-back and Global Anti-Pass-Back to deter tailgating. This shall mandate a user to flash access card at each access point whether entry or exit. Bypassing any access point deactivates the access rights of the user. Local refers to the entry and exit of a single access door/point and Global means the entry & exit points of multiple doors.
- The ACS Module shall support allocation of extended access time to some specific users like physically challenged users who need extra time to move in and out. The extended access time shall be configurable in the Module and the access control rules shall be applicable accordingly to such users.
- The ACS Module shall have the option to define Time Code which means the total duration of time in a day when users/Employee can get access through

the access barriers/doors. This shall be configurable between 00:00 hrs. to 23:59 hrs. It shall be possible to define multiple time codes.

- The ACS Module shall have option to define multiple holidays up to unlimited number of days. The interface shall provide option to make a specific holiday as repeating holiday which means the holiday will automatically get repeated on the same day of upcoming years also. Further, the Module shall provide the option to group multiple holidays so that all branches available in different geographical locations can have their regional holidays to be applicable on access rules.
- The ACS Module shall support defining of Time Zone that are the combination of Time Code and Holiday groups applicable to number of days in a week. The access rule shall work according to the defined Time Zone. It shall be possible to create Multiple Time zones in the system.
- The ACS Module shall allow grouping of access readers for user/Employee access. The list of all the installed readers shall be available in this section that can be grouped floor-wise, area-wise, or location-wise.
- The ACS Module shall further support combining Time Zone and Reader Groups to create Access Groups. It shall be possible to define it either for Employee or Vehicle and applicable to Visitor as well. All users/vehicles shall be issued these Access Groups and the respective time code, time zone, holidays and readers shall be available for that user to get access to the premises.
- The Access Groups shall also support the functionality of Shared access Groups which means an access group can be made applicable to multiple branch users. The users of different branches can be issued with this shared access group, and they can access multiple branches using the same access credential.
- The ACS Module shall support the Multi-man Access rule in such a way that for getting access from a particular door, it shall become a mandate for all the users in the Multi-man Access Rule to show their credentials.
- The ACS Module shall support the allocation of access rights to Visitors, also to track a visitor.
- The ACS Module shall provide real real-time occupancy count of the whole location or any of the areas.
- The ACS system shall have the capability to unlock, lock, or permanently lock specific doors or groups of doors within a controller. This functionality can be initiated by entering a predefined PIN, enabling quick response to scenarios such as evacuation or lockdown.
- The ACS system shall be able to schedule pin entry suppression on the pin reader. For instance, they can set card-only access between 9 AM to 6 PM and card + pin entry between 6 PM to 9 AM, allowing for flexible access control based on specified time intervals.
- The ACS system shall support 'double tap' feature where specific credentials.
- The ACS system shall have the ability to create a custom field with unique attributes. If marked as unique, the field's value must be distinct across the entire company. Additionally, the user can set a custom field as compulsory, ensuring that an employee profile cannot be added or edited without providing

this value. Furthermore, dropdown type custom fields allow users to define multiple options for the field, including a default value.

- The system should support precision access refers to user-specific access rights designated by readers and time zones. With precision access, users have the flexibility to assign or remove reader-wise access for each individual Employee. This level of customization allows for fine-tuned control over access permissions based on specific requirements.
- The system must allow manual activation/deactivation of relays via software, even if the relays are not mapped with any input. This feature provides users with the ability to control relays directly through the software interface, enhancing flexibility and facilitating specific actions as needed.
- The application should support Global/Regional IO mapping, enabling users to establish peer-to-peer communication between controllers. With this feature, users can create IO mapping rules to execute global IO actions. For instance, in the event of a fire input, users can unlock all doors across multiple controllers, eliminating the need for dedicated fire inputs for each individual controller or server-based 'open-all-door' functionalities. This streamlines access control management and enhances operational efficiency.
- The application needs to support input masking in controllers. Input masking involves disabling specific inputs. When an input is masked, any configured rules associated with it will not be executed upon status change. However, users should have the option to configure inputs in a way that allows a masked input to either generate or prevent status change events.
- The application should be able to groups of doors from various controllers and use that group to lock/unlock doors in bulk from the application interface.
- The application must include a feature to create a procedure that resets the Anti Pass Back for all Employee upon the activation of a specified time zone. For instance, every day at 8 AM, the Anti Pass Back should be automatically reset for all Employee, ensuring a hassle-free entry in the morning. This functionality allows for smoother access control operations and ensures that Employee can freely access designated areas without restrictions during the specified time zone.
- The application should implement distinct grids for input and output sections to clearly display the status of inputs and outputs. This differentiation will provide users with a clear overview of the current state of both inputs and outputs. Additionally, upon clicking on a specific input, the application should allow users to view the corresponding mapped outputs. This feature enables users to quickly identify which outputs are associated with a particular input and take necessary actions on those outputs as needed. Such interactive functionality enhances the user experience, making it easier for them to manage and control inputs and outputs effectively.
- The application must incorporate door masking, which should include the ability to enable door held masking and door forced masking. This feature is essential to allow users to disable door held/force events selectively for individual doors or groups of doors. The door masking functionality should be achieved through two methods: firstly, users must be able to create controller-based IO mapping rules to mask a door using inputs, time zones, double taps, pin commands, and other relevant parameters. Secondly, users must have the

capability to mask specific doors or groups of doors directly by issuing commands from the security view. The implementation of door masking is crucial for providing users with enhanced control over door events, ensuring a more flexible and secure access management system.

- The application should have the capability to analyse user access attempts even after access has been granted. It must verify the legitimacy of the user for the granted access and identify if the access was unauthorized. In such cases, the system should display the access attempt as "unauthorized grant access" and provide a clear reason for the denial. This functionality is essential to enhance security measures and ensure that only legitimate users have appropriate access rights, helping to identify and address any access control issues promptly and effectively.
- **Evacuation Management**
 - The ACS Module shall support configuring some specific readers as muster point readers at the assembly points.
 - In case of a fire/emergency alarm all the access points shall get automatically disabled and all the people present inside the premises shall be able to freely reach to the assembly points.
 - The users will show their credentials on the muster point readers installed on the Assembly Points to mark them as present on Assembly points.
 - The system shall show, on real time basis, the information about how many people is present at the assembly points and how many are not. Those who are not present at the assembly point during this exercise/real emergency their tentative location shall be shown based on the last card action on any of the access readers.
 - It shall be possible to get a dashboard on the user interface having real time updating widgets regarding the emergency evacuation and area wise head count.
- **Guard tour Management**
 - A guard tour system helps companies and organizations efficiently organize, log, and execute patrols using existing access control inputs and readers.
 - It ensures security officers accomplish tasks within predefined intervals, provides real-time monitoring and alerts for missed checkpoints, streamlining security measures without the need for additional devices.
- **Alarm management & Monitoring**
 - **Alarm Management**

This Module must have the following minimum characteristics to assign manage and mitigate risks and faults: Alarm class, escalation, Instructions, remarks, policy & Assignment of such policy.

 - ✓ Alarm class must have different classifications of alarms like Critical, warning, attention & Normal. The classifications must have interchangeable colour codes and text colour for easy identification.
 - ✓ Alarm Escalation means the different escalation matrix an alarm must follow in case of an alarm situation. This module must be user configurable for different types of alarms with escalation levels up to 5 and with time duration for each escalation selectable to minutes/ hours/ days and person/ user to escalate to.

- ✓ Alarm Instructions: the application must have a clear and user definable up to 5 sets of instructions for each type of alarm so that a security personal who will receive a pop on the screen may the action based on instructions.
- ✓ Alarm remarks: each alarm must have a set of dropdown instructions which can be set so that after an action is taken by security, he may choose a remark for each for future reference and quick response.
- ✓ All alarm management modules must support setting a specific priority for each alarm type.
- ✓ Application must support for each type of alarm if acknowledgement is required or not based on site requirements and alarm type.
- ✓ Application must support for each type of alarm if remarks is required or not based on site requirements and alarm type.
- ✓ Security admins should have the flexibility to create a comprehensive alarm policy definition for every type of alarm by choosing an escalation matrix of their choice, and set of predefined instructions, and choose a type of classification, and for ease of response have a preset remarks to select from so that the over implementation and compliance for rules and policies are easier.
- ✓ The applications should support different types of notifications for alarms like popups, email, and Push notifications to mobile applications for specific predefined personals.
- ✓ The application must support an alarm policy to be assigned to only certain readers, inputs or controllers as per requirement.

➤ **Live Monitoring**

The Application must support a comprehensive live monitoring module with following aspects. Controller/ Device status, Interface status, door status, input status, reader status, Live events, Reader event live view, Event history, who's were, Area count.

- ✓ Controller status window must show the live status and information of controller or devices which are configured on the application with information such as Name of device, branch, type of device, MAC Address, IP Address, Online or offline status, time of last communication.
- ✓ The Interface Status window must show the live status of interfaces connected to controllers with information such as Name of device, branch, type, panel address, Port, or type of communication, and online or offline status.
- ✓ Door status live monitoring window must show details of the name of the door, branch, type of door, Door status open/ closed, Lock status locked/ unlock, Door held alarm active or inactive, door forced violation, door forced alarm, tamper violation.
- ✓ It should be possible on the Door Monitoring window to select any door and to lock/ unlock or permanently lock or disable the lock remotely.
- ✓ On the Door monitoring application interface, it should be possible to mark any door as 'under maintenance' and select an action like activate/ deactivate Forced open alarm masking or activate/deactivate held open alarm masking.

- ✓ It shall be possible to 'Lockdown' all doors or 'Emergency Evacuate' of the branch from door monitoring window or reset to 'normal'.
- ✓ Input/ Output Monitoring window shall support monitoring live condition of all inputs and outputs and mask any input or activation/deactivation of all outputs.
- ✓ Reader status window shall show the live status of all branch readers by their name, controller connected to, branch, status active/ inactive, Tamper status.
- ✓ Events Window shall show all comprehensive live events and alarms as defined in the alarm policy with live pops of alarms and information such as what, where, branch, who, when, Acknowledgment status.
- ✓ Live view window shall allow pops and shall show alarm class by the text colour and colour code so that it's easier to identify.
- ✓ Alarms popups must have live view window from the CCTV camera connected and shall also support moving camera angle if it's a PTZ camera.
- ✓ Live view Popups should allow for incident view of the camera where it shall show the actual footage of the event from CCTV systems archives.
- ✓ Popups also give instructions to security staff manned at the station as configured in the alarm management system and shall allow up to 5 sets of instructions.
- ✓ Popups shall also allow the security staff manning the station to apply preset remarks or type remarks for each alarm event for future reporting.
- ✓ Reader Live view window shows the events of a single reader with details of users who have last swiped. The details shall include information such as Access granted or denied, ID, Name of personal, Card type, Photo, Card Issue date, Department, Designation, expiry date of the card. This helps security personal near the door to monitor the face of person entering with the photo in the application.
- ✓ Event history window allows users to view and download past alarms and events based on period event type, alarm class, branch, acknowledgment status.
- ✓ The Who's Where window allows users to check the current location of people inside the premises with the help of their last card action. This is made easier by searching the application based on branch, searching based on Employee ID/ First name/ Location.
- ✓ Area Count shows the total live headcount of Visitors and Employee present at different locations of the premises.
- ✓ Access control Module shall support Intelligent auto event popups for various access control events based on policy definitions.
- ✓ Access control system shall be capable of notifying users or admins of various alarms via SMS or email.
- ✓ The system should enable users to monitor the real-time connection status of interfaces. Additionally, changes in the interface connection status should be tracked and viewed on the event monitoring page, ensuring continuous monitoring and better visibility of interface connectivity.

- ✓ The application must support monitoring cabinet tamper and power monitor inputs across all controllers and interfaces. These inputs should be in-built and come with fixed NO or NC mode. Users can define IO linking rules against this input, allowing them to utilize it for general purposes as well, providing flexibility and enhanced functionality.
- **Graphical User Interface for Monitoring**
 - ✓ It shall be possible to create a Graphical User Interface (GUI) by uploading floor maps in image formats into the Module.
 - ✓ The Module shall provide default icons to drag and drop on the floor maps GUI and shall be mapped with the actual device behind that icon. for example, a lock icon, alarm icon etc.
 - ✓ The icons once mapped with the actual devices shall change its appearance according to the change in the status of that device. for example, if an alarm hooter is activated then the alarm icon shall start flashing on a particular location on the GUI where actually the alarm is hooter is activated. In this way the entire GUI shall be highly interactive.
 - ✓ It shall be possible to divide the floor maps into different logical areas which can be mapped with the real entry & exit device to find out the Occupancy in each logical area. These occupancy details shall further provide the possibility of knowing who all are present in those logical areas.
 - ✓ It shall be possible on the GUI to drag and drop CCTV Camera Icons and map those icons directly with the actual camera. This shall enable real time video view on any selected camera within the access control Module GUI.
- **Reporting Module**
 - The ACS Software shall provide a centralized reporting module that can provide multiple categories of reports based on the different functional requirements like:
 - ✓ Attendance Reports.
 - ✓ Access Reports.
 - ✓ Vehicle Reports.
 - ✓ Employee Audit Log reports.
 - ✓ Card Audit Log Reports.
 - ✓ Biometric Enrolment report.
 - **Reporting Module Standard Features**
 - ✓ The section shall provide the option to filter the reports based on days like today, weekly, monthly & and custom date (from date – to date selectable).
 - ✓ Further filtration shall be supported based on Employee criteria like Employee, branch, and department, selectable.
 - ✓ It shall provide ordering of reports based on various parameters like Employee name, Employee id, shift name, etc., in ascending or descending order and then by parameters like date of duty, first login, last logout, etc., again in ascending or descending order.
 - ✓ The reports shall be available at least in CSV and pdf format.
 - ✓ Besides the standard reports the system shall allow customized report templates to be created utilizing the above filtering and ordering along with

enabling and disabling any field and sequencing of rows and columns. These customized reports shall be saved as templates to be generated at any time by the user.

- ✓ The system shall support report scheduling which shall enable to user to create a criterion and save it for the system to create, generate, download, and send the report to the provided email ID in the criteria.

- **Access Reports**

- Individual Access Report: In this section, the user shall generate an access (In/Out) report of the Employees.
- Reader Access Report: In this section, the user shall generate an access report based on a specific reader.
- Reader Group Access Report: In this section, the user shall generate an access report based on a reader group.
- Card Not Shown Report: In this section, the user shall generate a report which gives details of Employee who have not shown their card for a specified number of days.
- Who's Where Report: In this section, user shall generate a report to find out the current area of the Employee's presence.
- Muster Point Report: This generates a report of all the Employees gathered at a muster point (Know Muster Point here)
- Individual Reader Assignment Report: In this section, the report will provide details about which reader is assigned to each Employee.
- Reader Assignment Report: In this section, the user shall generate a report showing the Employee who are provided access to a particular reader.
- Guard Tour Report: In this section, the user shall generate a guard tour report by scanning all the checkpoints used during the guard tours.
- Employee Verification Report: In this section, the user shall generate the reports of Employee verified by the tab application (verified by authorized supervisor).
- Logical Access Report: In this section, the user shall generate a report which consists of login and logout details of users/ Employee who accessed Access Control Software Web Interface and Client Interfaces.
- Biometric Enrolment Report: Generate a report of Employee(s) enrolled through various biometric/ biometric enrolment devices.
- Employee Muster Point Report: Generate a muster point report of Employee(s), i.e., who all get gathered in an area during a specified period.
- Visitor Muster Point Report: Generate a muster point report of the visitor(s) i.e., whom all gather in an area during a specified period.

- **Employee Audit Log Reports**

- Employee Card Assignment Report, in this section, the card assignment history of Employee(s) shall be audited.
- Employee Access Rule Assignment History, in this section, the access rule assigned to the Employee(s) for a particular time period shall be audited.
- Employee Current Card Report, in this section, a detailed report shall be generated elaborating details of the current cards issued to the Employee with date and time.

- Employee Current Access Rule Report, in this section, the user shall generate a report that provides details of the current access rule assigned to the Employee(s).
- **Card Audit Log**
 - Card Life Cycle Report, in this section, the user shall generate a report to get the details of the life cycle of a card (such as activation date, assigned Employee, etc.)
 - Access Rule Assignment History, in this section, the user shall generate a report listing the access rules associated with cards used in the access management process
 - Card Current Status Report, in this section, the user shall find the current status of the linked cards such as issued, available, active, inactive, suspended, and lost.
 - Card Current Summary, in this section, the user shall get summarized information of card details.

1.4.3 Access Control System Software

Access Control Module

- Centralized, Flexible, Expandable architecture and Customizable platform.
- Application should be developed using flexible MVC framework
- Allows managing multiple companies, locations, systems; no limitation on adding companies and locations
- Intelligent tool to get details of newly added network controller automatically
- Manage employee details and access restrictions.
- Assignment of TWO Credentials to one Employee (Card / Biometric & Mobile Access Credential)
- Bulk import of cards
 - If the organization is having large number of employees, the application has the facility to import all card numbers in bulk from excel sheet in a specific format. User can download this specific format from application itself. This facility reduces the time required for data entry.
- Card Inventory & Card Audit Feature
- Supports multiple card formats on same system
 - Support up to 253 card formats. (in case of HID Controllers)
 - 26- bit card format, 32- bit, 34-bit card formats and 35- bit corporate 1000 format. (In case of HID Controllers)
 - Support custom card formats.
- Facility to read unknown card Formats
 - If card format is not known the application can accept raw hex value.
 - Select any reader from application, show unknown card format on selected reader.
 - Application gives information about Facility code and card number of the unknown card.
- Manage Multiple Access Groups; manage up to 65535 access groups
- Manage Multiple Time Zones: no limitation on time zones
- Manage Multiple Door Groups: no limitation on Door Groups
- Manage Multiple Holiday Groups: no limitation on Holiday Groups

- Manage Extended Access and Pass-back Exempt
 - User can define normal access grant time, for physically challenged employee as it's not possible to pass through the door as per normal access grant time.
 - Application has facility for such Card holders to assign extended access time so that door force alarm should not generate.
 - Application has facility of anti-passback but for some key peoples in the organization we can bypass the anti-pass back by exempting them.
- Timed/Real Anti-passback for area control
 - If you set Time Anti-Passback then user cannot get access once he swaps the card for particular time interval which is defined.
 - If you set Real Anti-Passback then at define area user gets normal access.
- Facility to reset Anti-passback for employee in case of emergency.
- Door Enabling, Disabling from Software
- I/O and alarm configurations like fire, door-held, door-forced, battery failure, AC failure, etc.
- Monitor and control I/O status in real-time.
- Real time alarm monitoring.
- Pop-up or SMS alerts on various alarm conditions (SMS's to be procured separately). User can receive various alarms from hardware such as:
 - Battery fails
 - AC fails
 - Tamper alarm and other alarms from I/O Linker.
 - Facility to reset all the alarms from application
- Elevator Control; to manage multiple elevator groups and employee groups.
- Door Interlocking
 - If the system requires the user to pass through two doors in a series to enter the premises and if the doors are interlocked, both the doors cannot be opened at a time. Thus, we can select more than two doors in a group.
- Bulk Import and Registration of employees.
- Fire alarm system integration
 - User can integrate fire alarm panel to the access controller so that through I/O linker the application can get the alarms in case of fire from fire panel.
 - User can reset the alarm received from fire panel from the application itself.
 - Based upon I/O linker grouping, the controller will take an action.
- Web-Based Reporting Module provided for easy accessibility.
- Utility for real-time transactions downloading.
- Database Management through Backup and Restore options.
- Audit log for all actions against each user.
- Facility to fetch time from Controller and Time Synchronization with PC/Server
- Active Directory / LDAP Integration for Authentication & Master Data Synchronization
- Supports Application Server Redundancy using Microsoft Windows Cluster
- The physical access control application can be integrated with windows AD (Active directory) to provide logical access (Windows Login) information Logs along with Physical Access Logs

- Facility to have a display screen near the security guard to flash the photograph & details of the employee whenever the employee flashes the card/biometric at the main entrance for visual authentication by the security guard.
- Integration with Milestone Corporate Version.
 - User can make reader & IP CCTV combination for each controller from controller and reader setting option. So That for each punch user can get clip or image from specified reader.
 - User can view live transactions from live window by selecting specific controller & reader. From same window user can open and close the doors for authorized person by clicking on open /close button.
 - From Live view window user can compare the stored image of the registered employee with the image/clip received from IP CCTV.
 - User can set Clip duration for the clip length required against each transaction.
 - User can view stored records from report menu with the stored image for comparison in case of forensic if required.
- Wide range of Reports provided with various filtrations which can be exported to a number of formats like PDF, Excel etc.
 - Employee Access Master
 - Access Granted
 - Access Denied
 - I/O Alarms
 - First In Last Out
 - Employee Registration
 - Unknown Card Swipe
 - Anti-Passback
 - Audit Log
 - Multi-Man
 - Access
 - Access Vehicles
 - Activity Log
 - Access Zone
 - Asset Assignment
 - Asset Transaction
 - Card Assignment
 - Department wise Privilege
 - Door wise Privilege
 - Driver Helper
 - Driver Helper Un-registration
 - Transaction
 - Card Activity Report
 - Master Registration Report
 - Activity Log Report
 - Agency Wise Summary Report
 - Photo ID Card Master Report
 - Access Zone Live Status
 - Emergency Situations Report
- Automatic scheduling of excel sheet report to defined Email ID's. Should have facility to send Auto emails to unlimited number of email ID's

- Consolidated report giving details of employee physical access and windows Network Logon Access (i.e. Should be able to get details of the employee/User as when he/she entered the premise, what time he/she logged in windows, what time he/she logged out windows & what time he/she left the premise.) all the time stamps from both physical & Login Access should be available for the particular employee in case of audit trail.
- Employee productivity report giving details on how much time the user was working on the system (from windows logon till logout/locked along with IP address of the PC from where the employee logged in.
- Woman Safety Feature: The application should have capability to intimate at central location by means of SMS & Email if ONLY one female employee is there within the organization
- Identity Analytics under Access Control to be part of the Centralized Dashboard. This feature should include the following:
 - Location-wise Employee Status Summary
 - Access Zone Occupancy
 - Card Inventory Summary
 - Transaction Summary
 - Top 10 Alarms
 - Top 10 Transactions
 - Door-wise Access Grant Details
 - Door-wise Transaction Details
 - Department-wise Employee Status Summary
 - Card-Format wise Employee Distribution
 - Last 7 days Anti-Passback Violation
 - Last 7 days I/O Alarms
 - Door-wise Unknown Card Swipe Details
 - Door-wise Access Denied Details
 - Controller Health Status
- Every User should be able to design its own dashboard in a 9X9 windowpane.

Time Attendance Module

- Web based architecture
- Add and manage multiple companies, locations, departments, designations.
 - No limitation on adding companies and Locations
- Real time system, on the fly data processing for attendance calculation
- Sections: Group employees into different sections governed by Section Heads for better control.
- Multi-user System with various roles and rights to operate system
- maintain Dynamic user hierarchy
 - Super admin
 - Section admin
 - Hierarchy
 - Employee
- Employee Management: Admin or HR person can add employees.
- Each Employee master consists of following details.
 - Company
 - Location
 - Department

- Sub Department
- Designation
- Code & Name of Employee
- Email ID
- Address
- DOB & DOL
- Joining Date
- Photograph
- Gender
- Multiple categories (attendance rules setting). Totally user defined settings.
- Punch Setting:
 - User can define which punch should be consider for time calculation.
 - User can define maximum Hrs allowed for employee continuously.
 - Provides much flexibility in punch selection for time attendance calculation.
- General Setting:
 - Work Hrs settings: User can define Min full day hrs and Min half day hrs.
 - Check IN time Setting: User can set punch time as a check in time
- User can set overwrite Shift In time as check In time
 - Application can Ignore punches with difference of less than specified time. (Time is user defined)
 - Application should round up work hrs to the nearest, Before and Next level. User can set the time slot.
 - User can set Compensation off setting as Min work hrs applicable for comp off and min extra hrs applicable for comp off. Also, user can set no of comp off in a month.
 - User can set Weekly Off in between absent days set as Absent.
 - User can set Holiday in between absent days set as Absent.
- Over time & Late/Early Setting:
 - User can set Overtime Starts After time
 - User can define Min OT hrs after Shift and Min OT hrs before Shift
 - Based on setting User can Consider OT for work on Weekly Off and Consider OT for work on paid holiday.
 - User can set timing for late and early timing based upon company rules.
- Shift Management: Multiple shift structures can be created including night shift. Shift rosters i.e., rotational shift patterns can be created & assigned to the employees. Flexi Shifts should be possible
- Intelligent and auto logic for night shift handling
 - User can set IN-OUT mode in category so that the employee who continues shift till next day, the report should generate for shift start date.
- Supports more than 24 work hours using IN/OUT readers
 - User can set two different readers for In and Out so that the entries from In reader should consider as IN and the entries from Out reader should consider as Out.
 - User can set the maximum hrs the employee can work continuously
- Holidays: Single or multi-day holidays can be added.
 - No limitation on adding holiday
- Leave Management: Can maintain various leave rules as per organization policies.
 - User can set the leave year

- User can define leave code as per company policy like CI, SL, PL etc
- Leave rule: User can set various rules as
 - Max no of days allowed
 - Max days allowed at a time
 - Max no of times allowed
 - Min days allowed at a time/ half day allowed
 - Weekly Off in between leave days set as leave
 - Holiday in between leave days set as leave
 - User can set leave opening balance
 - User can send request to section head for leave sanction.
- Leave Carry forward: Leaves will be carried forward from previous year balance.
- Leave Opening balance: User can define leave opening balance.
- Manual Punches: Facility to add manual punches has been provided for attendance adjustment
- Compensation Off: Comp-off can be given to an employee if he has worked on holiday/weekly-off day or based on his extra working hours.
 - User can set Compensation off setting as Min work hrs applicable for comp off and min extra hrs applicable for comp off. Also, user can set no of comp off in a month.
- OD (Outdoor Entry): No of hrs can be defined to mark outdoor entry which means time utilized for official work outside office which gets added into the work hours.
- Tour Entry: Tour entry can be added if the employee is outside for single/multiple days for official work.
- Special Entry: This is a special feature provided where-in the admin can over-write the day status of an employee as present or half-day.
- Overtime Request & Approval: Section head can request for bulk overtime approval of all employees under him which can be sanctioned by the authorized user.
- User Hierarchy: There are 4 different user profiles in the system i.e., Admin, Section head, Hierarchy admin (Company, location, department, or sub-department admin) and Employee.
- Employee Login: Employee can log into the system & track his attendance & also apply & track status of various requests like manual punches, leave, tour, outdoor entry etc.
- Online Request Management: E-mail can be configured to be sent for various requests like manual punches, leave etc. The authorized admin can also handle these requests online without logging in to the software & the employee is notified back by an e-mail about the request status.
- Bulk import & export of employees provided.
- Application has facility of bulk import & export of data for following:
 - Import master data
 - Import shift roaster
 - Import export employee data
 - Import leaves opening balance
- Application has standard format to import the data in a specific format.

- Integration with ANDROID based application to Mark 'Check IN' & 'Check OUT' from the remote location with capability to capture Geo location of the Employee who marks the attendance
- Integration with 3rd Party payroll software.
 - Application has the open architecture and centralised data base so that other application like 3rd Party Payroll & HR software can be integrated with Time attendance software.
 - With Access control software we can define specific reader for IN-OUT for attendance purpose.
 - The data received from Access control application should be processed in time attendance software and the processed the data can be used for payroll
 - Integration with SAP HRMS (existing application) using Database Table View
- Audit log for all actions against each user.
 - Application has facility for audit log report this gives user details with company, date, time and location of login
- Attendance calculation analysis shown for support
 - Attendance analysis gives punch details about previous day, current day and next day.
 - Report shows shift applied and category applied for the employee
 - Based upon settings analysis report gives summary for day status, total work hrs, extra hrs, break time, late time and early time
- Work from Home Feature - Facility for the Employee to send the request for "Work from Home" for Manager
- Approvals from the Employee Login
- Absent Employee Auto Alert to Manager
- Active directory integration
- ERP report: The user can configure the report settings & generate report in any required format.
 - User can set report for ERP as report header, date format, date separator, field separator and row terminator.
 - User can select the field required for ERP report just by drag-drop option.
 - User can add custom text field and can add column header
- Wide range of Reports provided with various filtration options which can be exported to a number of formats like PDF, Excel etc.

Note: Successful bidder / Contractor shall be submitted the technical datasheets of above technical requirement in the form of Compliance document. No deviation shall be accepted. The Access Control System Software shall have an inbuilt feature as mentioned below

- Security Access Control Module
- Vehicle Access Control Module
- Attendance & Time Management Module (HRMS)
- Video System Interface (CCTV) Module
- All the above features shall be provided as a part of Access control System Software Cost. However, the IBMS integration shall be done through Software & Hardware level without adding any additional third-party devices.
- Graphical Reports
 - Working Hrs Histogram
 - Attendance Summary

- Identity Analytics under Time Attendance to be part of the Centralized Dashboard. This feature should include the following:
 - Online Status Summary
 - Pending Requests Summary
 - Location-wise Employee Status Summary
 - Birthday's Today
 - Department-wise Employee Status Summary
 - Shift-wise Employee Status Summary
 - Continuous Late Coming
 - Continuous Absentee
 - In time Statistics
 - Attendance Statistics
 - Continuous Early-Going
 - Location-wise Employee Count
- Every User should be able to design its own dashboard in a 9X9 windowpane

1.4.4 Specifications of Intelligent IP Master Controller

General Requirements:

- The intelligent controllers and peripheral interface devices must provide an open architecture family of products that enables a choice of host software system vendor without replacement of hardware.
- The Linux based intelligent controller must provide decision making, event reporting, and database storage as a hardware platform. Two reader interfaces shall provide control for two doors in addition to supporting a total of 64 doors, paired and or alternate reader configurations with peripheral interface devices. The intelligent controller will support up to 64 readers in total.
- The intelligent controller shall communicate with the host via on-board 10BaseT/100BaseTX Ethernet port and support TLS encryption as a minimum-security implementation.
- The intelligent controller must be capable of elaborate processes and procedures without host intervention. Once configured, the intelligent controller must function independently of the host, and must be capable of controlling access, managing alarms, interfacing with an array of hardware devices, all while providing the decision-making oversight that each system configuration requires.
- The intelligent controller must support a wide range of reader technologies, including OSDP, Wiegand and magnetic stripe.
- The intelligent controller shall control two physical barriers and up to four (using OSDP) or two (using Wiegand) readers.
- The intelligent controller shall support, as a minimum the following open standards: OSDP, OSDP SC, SNMPv3/v2c and 802.1X.
- The intelligent controller must utilize a cryptographic module, like OpenSSL FIPS Object Module RE, that is validated to FIPS 140-2 thus providing a certified implementation of TLS.

Technical Specifications

- The Master Controller is for use in low voltage, Class 2 Circuits only
- The installation of this device must comply with all local fire and electrical codes
- Primary Power: 12 to 24 Vdc $\pm$ 10 %, 1.9A (550 mA excluding readers)

- Micro USB Port: 5 Vdc 500 mA maximum (reserved for future use)
- Memory and Clock Backup Battery: 3 Volt Lithium, type CR2032
- microSD Card: Format: microSD or microSDHC; 2GB to 8GB (reserved for future use)
- Host Communication: Ethernet: 10Base T/100Base-TX
- IO Module Communication: Two independent ports, 2-wire RS-485, 2,400 to 115,200 bps, asynchronous, half-duplex, 1 start bit, 8 data bits, and 1 stop bit
- Inputs: Seven unsupervised/supervised, standard EOL: 1k/1k ohm, 1%, ¼ watt (includes TAMPER, AC FAIL and BATT FAIL inputs)
- Outputs: Four relays, Form-C with dry contacts
 - Normally open contact (NO): 5 A @ 30 Vdc resistive
 - Normally closed contact (NC): 3 A @ 30 Vdc resistive
- Reader Interface
 - Reader Power: 12 Vdc $\pm$ 10 % regulated, 500 mA maximum for each reader
 - Data Inputs: TTL compatible or two wire RS-485 standards supported. Maximum cable length (TTL/Wiegand): 500 ft. (152 m)
 - OSDP (RS-485) Mode: 9,600 to 230,400 bps, asynchronous, half-duplex, 1 start bit, 8 data bits, and 1 stop bit. Maximum cable length: 2000 ft. (609.6 m)
 - LED & Buzzer Output: 12 Vdc open circuit maximum, 40 mA sink maximum
- Cable requirements:
 - Ethernet: CAT-5, 328 ft (100 m)
 - Readers-OSDP: 4 conductor twisted pair over-all shield. 2000 ft (610 m) maximum. Utilize one pair for data and one pair for power.
 - Readers-Wiegand/C&D: 4-conductor, 18 AWG, shielded, 500 ft (150 m) maximum)
 - IO Modules: One twisted pair, shielded. 120-ohm impedance, 24 AWG, 4,000 ft (1,219 m) maximum
 - Alarm Inputs: One twisted pair, 30 ohms maximum, typically 22 AWG @ 1000 ft. (304.8 m)
 - Power and Relays: 2-conductor shielded, 18 to 16 AWG, 500 ft (150 m)
- Environmental:
 - Temperature:
 - ✓ Operating: 32 to 158°F (0 to +70°C)
 - ✓ Storage: -67 to 185°F (-55 to +85°C)
 - Humidity: 5 to 85% RHNC
- Product Compliance:
 - FCC Part 15 Sub-part B, CE, BSMI, IC, AS/NZS, TCVN, KCC, VCCI
 - UL-294 Recognized Component
 - IEC 62368-1
 - CB Scheme
 - RoHS (2011/65/EU & 2015/863)
 - EU REACH (1907/2006)
 - California Proposition 65
 - NIST Certified Encryption

Technical Features

- Security and Network:
 - IPv4/v6
 - Host/Controller connection protected by TLS 1.2/1.1 or AES-256/128

- Controller/IO Expansion connection protected by AES
- Generate and load custom peer certificates for TLS
- Port based network access control using 802.1X
- Crypto memory chip
- FIPS 140-2 user of OpenSSL
- HTTPS protection for installer web pages
- Secure cookies
- SNMPv3/v2c
- DIP switch toggle sets five (5) minute time to disable webpage access
- Disable default login credentials
- Authorized IP address filtering
- IP Client Proxy
- Bulk erase controller and periphery devices during replacement
- Strong password enforcement
- Door Control:
 - Two-reader ports: RS-485, Wiegand or Clock-and-Data
 - Seven programmable inputs, four relays, diagnostic LEDs
- Access Control:
 - 250,000 Cardholder capacity
 - 50,000 Transaction buffer
 - If/Then Macro capability
 - Adjustable cardholder capacity
 - Supports up to 615 inputs and 388 outputs
- Card Formats:
 - 8 card formats per active reader
 - Entire card number reported on invalid read
 - 19-digit (64-bit) User ID and 15 digit PIN numbers maximum
 - 32 Access Levels per card
 - Activation/Deactivation Date or Date & Time
- Card Reader Functions
 - Multiple card format support by reader
 - Paired reader support
 - Alternate reader support
 - Elevator support
 - Turnstile support
 - Open Supervised Device Protocol (OSDP) and OSDP SC compliant
 - Occupancy count
 - Support of multi-occupancy rules
 - Anti-passback support
 - ✓ Area-based, reader-based, or time based
 - ✓ Nested area, hard, soft, or timed forgiveness
 - Supports host-based approval rules
 - Keypad support with programmable user commands, card input
 - Shunt relay support
 - Strike follower relay support
 - Threat level and Operating Modes
 - Host controlled OSDP reader passthrough
 - Elevator floor override

- Database Functions
 - Encrypted database
 - Configurable card database
 - Supports card numbers up to 64-bits in length
 - Supports pin codes up to fifteen (15) digits
 - Programmable card activation and deactivation times and dates
 - Card issue code of up to 32 bits, ADA and VIP flags
 - Ability to track people and objects
- Supported Integrations
 - Supports up to 2 RS-485 IO protocols
 - Equivalent to Signo/iCLASS SE Card Compatibility using HID Reader Manager Desktop add-on app
- System Functions
 - Relay count activations
 - Interoperability with older host software using Legacy Mode feature
 - Synchronize time using NTP

Note: Successful bidder / Contractor shall be submitted the technical datasheets of above technical requirement in the form of Compliance document. No deviation shall be accepted.

1.4.5 Technical Specifications of Reader Module

General Requirements:

- Reader Modules and peripheral interface devices must provide an open architecture family of products that enables a choice of host software system vendor without replacement of hardware.
- The peripheral interface device shall control two physical barriers and up to four (using OSDP) or two (using Wiegand) readers.
- The peripheral interface device shall support a wide range of reader technologies and protocol/electrical signaling standards, including OSDP (RS-485), OSDP SC (RS-485), Wiegand (TTL), magnetic stripe, F/2F and biometric. Wiegand and magnetic strip protocols must support one or two wire LED controls, and buzzer control.
- The reader ports of the peripheral interface device shall be capable of supporting multi-dropped OSDP readers.
- The peripheral interface device shall be able to utilize a cryptographic module that can encrypt/decrypt communication with the intelligent controller, supporting AES encryption using a minimum 256-bit key length.
- The peripheral interface device shall utilize a crypto memory chip that provides hardened protection of secrets such as OSDP secure channel keys.

Technical Specifications

- The Reader Module is for use in low voltage, Class 2 circuits only
- The installation of this device must comply with all local fire and electrical codes.
- Primary Power: 12 to 24 Vdc $\pm$ 10 %, 1.5A (340 mA excluding readers)
- Communication with Intelligent Controller: 2-wire RS-485 2,400 to 115,200 bps, asynchronous, half-duplex, 1 start bit, 8 data bits, and 1 stop bit
- Inputs: Seven unsupervised/supervised, standard EOL: 1k/1k ohm, 1%, ¼ watt (includes TAMPER, AC FAIL, and BATT FAIL inputs)

- Outputs: Four relays, Form-C with dry contacts
 - Normally open contact (NO): 5 A @ 30 Vdc resistive
 - Normally closed contact (NC): 3 A @ 30 Vdc resistive
- Reader Interface
 - Reader Power: 12 Vdc $\pm$ 10 % regulated, 500 mA maximum for each reader
 - Data Inputs: TTL compatible or two wire RS-485 standards supported. Maximum cable length (TTL/Wiegand): 500 ft. (152 m)
 - OSDP (RS-485) Mode: 9,600 to 230,400 bps, asynchronous, half-duplex, 1 start bit, 8 data bits, and 1 stop bit. Maximum cable length: 2000 ft. (609.6 m)
 - LED & Buzzer Output: 12 Vdc open circuit maximum, 40 mA sink maximum
- Cable requirements
 - Readers-OSDP: 4 conductor twisted pair over-all shield. 2000 ft (610 m) maximum. Utilize one pair for data and one pair for power.
 - Readers-Wiegand / C&D: 4-conductor, 18 AWG, shielded, 500 ft (150 m) maximum)
 - IO Module: One twisted pair, shielded, 24 AWG, 120-ohm impedance, 4,000 ft (1,219 m) maximum
 - Alarm Inputs: One twisted pair per input, 30 ohms maximum, typically 22 AWG, 1000 ft. (304.8 m)
 - Power and Relays: 2-conductor shielded, 18 to 16 AWG, 500 ft (150 m)
- Environmental
 - Temperature:
 - ✓ Operating: 32 to 158°F (0 to +70°C)
 - ✓ Storage: -67 to 185°F (-55 to +85°C)
 - Humidity: 5 to 85% RHNC
- Product Compliance
 - FCC Part 15 Subpart B, CE, BSMI, IC, AS/NZS, TCVN, KCC, VCCI
 - UL-294 Recognized Component
 - IEC 62368-1
 - CB Scheme
 - RoHS (2011/65/EU & 2015/863)
 - EU REACH (1907/2006)
 - California Proposition 65

Technical Features

- Card Formats:
 - Eight active card formats per intelligent controller
 - 19-digit (64-bit) User ID and 15 digit PIN numbers maximum
- Card Reader Functions
 - Multiple card format support by reader
 - Paired reader support
 - Alternate reader support
 - Elevator support
 - Turnstile support
 - Open Supervised Device Protocol (OSDP) and OSDP SC compliant
 - Occupancy count
 - Support of multi-occupancy rules
 - Anti-passback support
 - ✓ Area-based, reader-based, or time based

- ✓ Nested area, hard, soft, or timed forgiveness
- Supports host-based approval rules
- Keypad support with programmable user commands, card input
- Shunt relay support
- Strike follower relay support
- Threat level and Operating Modes
- Host controlled OSDP reader passthrough
- Elevator floor override
- Database Functions
 - Supports card numbers up to 64-bits in length
- Offline mode operation
 - Door mode
 - ✓ Unlocked, locked, facility code only
 - Relay Mode
 - ✓ Programmable for offline conditions

Note: Successful bidder / Contractor shall be submitted the technical datasheets of above technical requirement in the form of Compliance document. No deviation shall be accepted. However, the Reader Module shall have inbuilt OSDP Protocol 4 Reader Connectivity. If the Reader Module does not have a OSDP Protocol scheme of operation, the scheme of proposals which can be submitting by successful bidder shall not be accepted.

1.4.6 Technical Specifications of Smart Card Readers

- The Multi-Technology contactless smart Card reader should be of Mullion Mount.
- The multi-technology contactless smart card reader must comply with the ISO 15693 and ISO 14443A 13.56MHz-related standards to ensure product compatibility and predictability of performance.
- The multi-technology contactless smart card reader must support communication frequency of 13.56MHz and 2.4 GHz (BLE)
- To ensure data authenticity and privacy the multi-Technology contactless smart card reader shall follow the standards-based, device-independent Security Identity Object™ (SIO) portable credential methodology. The SIO shall be able to reside on any number of identity devices, including Seos, iCLASS SE, iCLASS SR, MIFARE Classic, and MIFARE DESFire EV1/EV2/EV3 credentials.
- To enable mobile access the multi-Technology contactless smart card reader must support Bluetooth Low Energy (BLE) and NFC card emulation mode.
- The multi-technology contactless smart card reader shall utilize Secure Element Technology to protect keys and ensure secure cryptographic functions. The secure element on the reader should be minimally rated with the international standard Common Criteria security evaluation, achieving an Evaluation Assurance Level of EAL 5+.
- To provide universal compatibility with most access control systems the multi-Technology contactless smart card reader shall support the SIA AC-01 Wiegand standard as well as secure, bidirectional communication in compliance with v2 of the SIA OSDP (Open Supervised Device Protocol) standard
- The Multi-Technology contactless smart card reader shall allow the reader firmware to be upgraded in the field without the need to remove the reader from the wall through the use of programming utilities or applications.

- The Multi-Technology contactless smart card reader shall have the ability to provide consistent optimal read range by implementing an automatic surface detection function that adjusts for mounting environment and manufacturing tolerances to enhance consistency of read performance
- The multi-technology contactless smart card reader shall reduce power consumption by as much as 50% through the use of Intelligent Power Management (IPM) technology
- The multi-technology contactless smart card reader must have an environmental rating of IP65 to withstand water and dust ingress commonly associated with outdoor mounting
- The reader must comply with local certification agencies such as including, but not limited to the following: UL 294/cUL, FCC certification CE including RoHS II, BIS etc.

Note: Successful bidder / Contractor shall be submitted the technical datasheets of above technical requirement in the form of Compliance document. No deviation shall be accepted.

1.4.7 Technical Specifications of Biometric reader

- The dual factor fingerprint biometric access control reader must support live capture of fingerprints for matching identification or verification for physical access control.
- To ensure interoperability, the biometric fingerprint reader must support ANSI-378 template standard (Template on Card).
- The fingerprint biometric access control reader must support a communication frequency of 13.56MHz and 2.4 GHz (BLE)
- The fingerprint biometric access control reader shall follow the standards-based, device-independent Security Identity Object™ (SIO) portable credential methodology. The SIO shall be able to reside on any number of identity devices, including Seos, iCLASS SE, iCLASS SR, MIFARE Classic, and MIFARE DESFire EV1/EV2 /EV3 credentials
- To ensure product compatibility and predictability of performance the reader must support the following standards: ISO 15693 and ISO 14443
- To provide universal compatibility with most access control systems, as features become available, the reader must support output card data in compliance with the SIA AC-01 Wiegand standard or v2 of the SIA Open Supervised Device Protocol (OSDP) over RS485 for access control data communication- in order to cover the widest possible use cases, the biometric must have the following interfaces:
 - One Wiegand Port In/Out Selectable
 - One RS-485 Port (OSDP)
 - One TTL Input/Output Selectable
 - One selectable Supervised Input/ TTL Output
- The dual factor fingerprint biometric access control reader shall be equipped with an EAL4+ certified Secure Element to protect keys and execute cryptographic functions.
- The dual factor fingerprint biometric access control reader must feature a multispectral sensor to capture fingerprint images from both the surface and the sub-surface, therefore delivering optimal biometric performance regardless of environmental and skin conditions

- The dual factor fingerprint biometric access control reader must support liveness detection capabilities, preventing spoof attempts leveraging fake fingers or latent fingerprints
- The dual factor fingerprint biometric access control reader must support multiple authentication modes:
 - Template on card for dual factor authentication with fingerprint and iCLASS Seos cards
 - Card Only for single factor authentication with supported HF physical cards or mobile credentials
 - Fingerprint Only for 1:1 single factor authentication – for up to 5,000 users in the device database.
 - Card + Fingerprint for 1: N dual factor authentication – for up to 2,00,000 templates in the device with physical access cards or mobile credentials
 - Combination mode: Card only or Finger only for single factor authentication with physical access cards or mobile credentials
- To ensure a consistent security level throughout the access control system the reader must support a standard based Secure Identity Object data model, both for standard and virtual badges. Within the Secure Identity Object data is secured with a wrapper that provides key diversification, authentication signatures, and encryption.
- The dual factor fingerprint biometric access control reader must connect to the web based Biometric Manager on a TCP/IP network and allow the following functions:
 - Remote Management of the reader
 - User Enrolment
 - System Configuration
 - Live Events Transaction for connected readers
 - Software and Firmware Update/Upgrade
 - Import User Credential from OEM Database
- The dual factor fingerprint biometric access control reader must be IP67 Indoor/Outdoor and IK09 Impact rated for outdoor installation.
- The reader must comply with certification agencies such as including, but not limited to the following: BIS, UL 294/cUL, FCC certification, CE, RoHS etc.

Note: Successful bidder / Contractor shall be submitted the technical datasheets of above technical requirement in the form of Compliance document. No deviation shall be accepted.

1.4.8 Technical Specifications of QR Code reader

Card type	EM Card / IC Card
Barcode type	QR, One-dimensional Code
Communication	Weigand / RS232 / RS485
Decoding Mode	Image decoding
Reading Direction (Barcode)	45° inclined plane with the lens
Reading feature	Auto-induction, Beep hint
Working Voltage	5~15V
Working Current	800mA
Reading distance (card)	3~6 cm
Reading Speed	<200 m/s

Reading distance (Barcode)	0~20 cm
Material	Tempered glass (code window)
Working humidity	10%~90%
Working temperature	-20° C ~ 70° C
Dimensions	Compatible to fit inside the Swing Barrier
Indicating light	Blue - Working Green - Feedback
Weight	As per the Swing Barrier Recommendation
QR code format	Code 128, Code 39, EAN-8, EAN-128, EAN-13, QR code, ISBN-13, Data matrix

1.4.9 Technical Specifications of Contactless smart cards

- The contactless smart cards (13.56Mhz support) must be compliant with the following standards:
 - ISO/IEC 7810 Physical characteristics, format ID-1: 5.40 cm x 8.57 cm x 0.084 cm
 - ISO/IEC 14443-A parts 1-4 Contactless integrated circuit cards with random UID
 - ISO/IEC 7816-4,3.1 ISO/IEC 7816-4:2005, Sections 5.2 (Data Objects) and 5.3 (Structures for applications and data) for the organization of all data on the card
 - ISO/IEC 7816-4:2005 Section 5.2.2 (BER-TLV data objects) for the encoding of data
 - ISO/IEC 7816-4:2005, Section 7.5 for the authentication methods
- Contactless smart card should have at least 8K memory and can store data for multiple application.
- Contactless smart card should have corporate 1000 programming to avoid the duplication of the card numbers.
- Contactless smart card should support multi-layered trusted management of secure identities using the portable Secure Identity Object data model.
- All cryptographic algorithms, modes of operation, protocols and mechanisms used by the card shall be based on open standards (such as ISO/IEC, NIST, IEEE, EN, ETSI) and not subject to any patents or royalty payments.
- A secure messaging algorithm established after mutual authentication will protect contactless communication between the card and the off-card application.
- Mutual authentication shall be based on ISO/IEC 24727-3 2008 with NIST SP800-56A or SP 800-108 session key derivation.
- Each secure session relies on diversified keys based on an underlying cryptographic 2-key TDES or AES128 algorithm setup at the start of each session and using secure messaging based on European Standard EN14890-1 as well as ISO/IEC 7816-4.
- The physical access control data stored on the card shall be protected using an encrypted AES128 bit algorithm, signed using a CMAC-96 (message authentication code).

- The physical badge construct shall consist of a composite material to ensure physical stability during Direct-to-Card (DTC) or retransfer printing processes.

1.4.10 Electro Magnetic Locks (EML)

- The magnetic lock shall consist of a magnet mounted onto door frame and a steel plate attached to the top of the door.
- The door shall be strongly closed when the magnet is energized with the steel plate bonded to it. Instant release shall be possible when power supply is cut off, providing fail safe operation.
- The door controller shall control the EML.
- The EM Lock shall be suitable for mounting single, double, flush, swing type, metal, glass, wooden doors with (or) without frames.
- The Vendor shall consider the required mounting accessories for the above in their lock cost.
- The EM Lock shall have a minimum holding force of 600 LBS for single leaf door & 1200 LBS for double leaf door.
- The rate shall inclusive of all fixing brackets, accessories for Glass Door, Wooden Door, and Metal Doors as per the site conditions. No extra cost shall provided by client for additional accessories.

1.4.11 Magnetic Contact

- The magnetic contact shall be of flush / surface mount type as required at site.
- The contacts shall be corrosion resistant and completely hermetically sealed.
- 5 million cycles of operation shall not affect the contact.
- This contact shall be used by the door controller to monitor the door status.
- The contact shall contain a hermetically sealed magnetic reed switch.
- The reed shall be potted in the contact housing with a polyurethane-based compound.
- Contact and magnet housing shall snap-lock into a 3/4" or 1" dia. hole.
- Housings shall be moulded of flame retardant ABS plastic.
- Color of housings shall be off-white, grey or mahogany brown.
- The magnet shall be made of Alnico V. Rare Earth Magnet shall be made of neodymium iron boron.
- The contact shall be suitable for wooden, glass & metal doors.

1.4.12 Emergency Release Box

- The emergency release box resettable press to open glass type, similar to a re settable manual call point and shall be green in colour. In case of any emergency, the plastic facia in the box shall be pressed to cut-off the power supply to the electromagnetic lock.
- A key shall be used to reset the Release Switch Box to normal close position. The emergency release box shall be truly resettable type without any need for changing the glass after every operation. Once the glass is pressed, the same shall be reset by using the reset key.
- There shall NOT be any need to change the glass for every operation. The re settable emergency release box shall have a relay contact which shall be monitored by the door controller.

- Whenever the emergency box is operated, an audio-visual alarm shall pop up in the ACS Workstation

1.4.13 Door Buzzer

- Vendor shall provide piezo electric type door buzzer. The buzzer shall preferably half white in colour and shall NOT be more than 2" in dia and 2" in height. The door buzzer shall start operating when the door time is elapsed between 2 card swipes and the door is NOT closed. The door buzzer shall keep operating as long as the door is open and when the door is closed the buzzer shall stop operating immediately.
- Also, the buzzer shall not operate if the cards are being continuously swiped in the reader even when the door is opened continuously.
- The vendor shall consider the required power supply for powering the buzzer. The buzzer shall also have the facility to control the volume depending upon the site & situation requirement.
- Vendor shall use the programmable IOs in the access controller to activate this function.

1.4.14 Access Control System Server

- Server, Windows Server Standard, SQL Server Standard. Intel Xeon Silver 3104 Processor, 8 MB L3 Cache, 6 Cores, 6 Threads 3 x 8GB RDIMM, 2666MT/s 1 x 1TB 10K RPM SAS 2.5in Hot-plug Hard Drive 2GB Network Card Windows Server 2016/2019 Standard, 104, 12 function key DD, 21" LCD Monitor, Wireless Mouse, USB Keyboard, CD/DVD Combo Writer, TCP/IP Connection.

Note: The Configuration mentioned is only Minimum requirement. Vendor to consider as per OEM recommendations in case of higher configurations shall be required as per project functional requirements and the bidder to consider the cost for the same & quote accordingly. The bidder needs to consider the same configuration if OEM will not have an objection for the mentioned specifications. No deviation shall be accepted. The ACS Server shall be Hot Redundant 1+1 Configuration. In the BoQ line item requires cost of redundancy server also. Hence, no additional cost shall be paid by client for Redundancy Server and the ACS Server should be Rack mountable Blade type. Tower type / Tabletop mounted server shall not be accepted.

1.4.15 Access Control Operator Workstation

- Intel core 9th Generation Intel Core i9 Processor by latest generation or better, 16GB DDR3 RAM, 64-bit operating system, 1TB SSD for OS and Security Center applications, with a minimum of 16 GB of free disk space to install the Security Center client application, 1TB SATA Hard disk with 7200rpm, GbE network interface card, DVD-RW standard keyboard & Mouse with Dual NVIDIA® GeForce® RTX 2080 video card with 21" FULL HD LED MONITOR. Minimum 4 HDMI, 1 parallel, 8 USB 2.0, 1 serial, 2 Ultra ATA/100, 2 optional IEEE1394, 1 USB Keyboard, 1 USB Mouse, 1 video, 1 Microphone jack, 1 Line-in jack, 2 x 1GBPS RJ-45 Interface Port

Note: The Configuration mentioned is only Minimum requirement. Vendor to consider as per OEM recommendations in case of higher configurations shall be required as per project functional requirements and the bidder to consider the cost

for the same & quote accordingly. The bidder needs to consider the same configuration if OEM will not have an objection for the mentioned specifications. No deviation shall be accepted.

1.4.16 Thermal printer

Print speed	Print speed 250 mm/sec
Column capacity	FONTS & STYLES Column capacity Paper width 80 mm, 48 / 64
Paper size	Paper size 79.50 ± 0.50 (W) mm x dia 83.00 mm, 57.50 ± 0.50 (W) mm x dia 83.00 mm
Print Speed	Print Speed 250 mm/sec
Print Speed receipt	Print Speed receipt 250 mm/sec
Printing Font	Printing Font ANK
Column capacity receipt	Paper width 80 mm, 48 / 64
Paper width	80 mm, 48 / 64
Character set	95 Alphanumeric, 18 set International, 128 x 43 Graphic
Characters per inch	22.6 cpi / 16.9 cpi
Dot density	203 DPI x 203 DPI
Colour Printing	Black
Printing Characters	Text (incl. Euro symbol), Graphics, Barcode
Interfaces	RS-232, USB 2.0 Type B, Drawer kick-out
Data Buffer	4 kB or 45 Bytes
Power Supply	AC adapter, C1
Power Consumption	Standby: 0.1 A, Mean: 1.8 A
Operating Voltage	24 V

1.4.17 Display / HMI Monitor

22" Monitor Detailed Specification	
Monitor	22 Monitor - P2219H
Diagonal Viewing Size	54.61 cm (21.5 inches)
Maximum Preset Resolution	1920 x 1080 at 60 Hz
Aspect Ratio	16:09
Pixel Pitch	0.248 mm x 0.248 mm
Pixel Per Inch (PPI)	102
Brightness	250 cd/m ² (typical)
Color Support Color Gamut (typical)	72% (CIE1931)8
Color Depth	16.7 million colours
Contrast Ratio	1000 1 (typical)
Viewing Angle	178°/178°
Response Time	8 ms (Normal) 5 ms (Fast) - (grey to grey)
Panel Type	In-Plane Switching Technology
Backlight Technology	LED Edge light System
Comfort View with Flicker-free screen	Yes
Display Manager Compatibility	Yes
Display Screen Coating	Antiglare with 3H hardness

22" Monitor Detailed Specification	
Connectors	1 x Display Port version 1.2, 1 x HDMI port version 1.4, 1 x VGA port, 1 x USB 3.0 upstream port (bottom), 2 x USB 3.0 downstream ports (side), 2 x USB 2.0 downstream ports (bottom)
Built-in Devices	USB 3.0 super-speed hub (with 1 x USB 3.0 upstream port), 2 x USB 3.0 downstream ports, 2 x USB 2.0 downstream ports
Adjustability	Height-adjustable stand (130 mm), Tilt (-5° to 21°)
Swivel	(-45° to 45°), Pivot (-90° to 90°)
AC input	voltage/frequency/current 100 VAC to 240 VAC / 50 Hz or 60 Hz $\pm$ 3 Hz / 1.5 A (typical)
Power Consumption	(Operational) 17W (typical) / 37W (maximum) ⁹
Power Consumption	Standby / Sleep Less than 0.3W
Environmental Compliance	ENERGY STAR®, EPEAT® Gold ¹⁰ , RoHS Compliant, TCO-Certified Display, BFR/PVC free monitor Arsenic-Free glass and Mercury-Free

1.4.18 Technical Specifications for Swing Barrier

- Each Swing barrier lane should have provision for recessed installation of 2 nos. smart reader and 2 nos. of Smart Card Readers and 2 Nos of QR code readers, each 01 on Entry side and each 01 on Exit. These readers should come factory fitted with the flap barrier as per site requirement.
- The design of the gate arrays should be such that the user uses the integrated reader placed on the right-hand side while passing through the gate.
- The gate of retractable type should be with material of enough strength for use in mass transit system.
- If the barrier is forced open, no damage shall happen to gate components and gate should automatically restore to normal. An alarm should be generated during such forced opening.
- There shall not be any sharp edge in the gate, which can hurt user while passing through.
- In case of emergency there should be provision for continuous opening of the gates to facilitate exit of personnel from the building.
- Emergency switch should be provided to facilitate easy exit of personnel.
- Sensor mounted above, below, and sideways the flap to generate an acoustic alarm for each unauthorized attempt, jumping over or crawling under the flap wings.
- There shall be selectively illuminated Lane Indicator sign on both ends of each gate. The display shall be illuminated whenever the gate is intended for use in the direction shown.

- Material to be used: 304 Grade stainless steel with thickness of 2 mm for housing.
- Retractable Flap wing: should be 12 mm thick transparent Acrylic/ toughen glass with rubber safety edge for the panels.
- Power supply: 220V AC, 50/60Hz.
- Sensor to detect person in safety zone: fully retract in case of power failure/emergency
- Card readers should be integrated with the flap barrier housing, for entry/exit.
- Motor: DC brushless, Protection IP20
- Minimum Dimensions: 1400 mm X 100 mm x 1000 mm (L x W x H)
- Channel/Passage Width should be in the range of 600mm for Normal Lane & 900mm for Wide Lane
- Pass Speed (Minimum): 40 Person / Min.
- Should be capable of operating in Indoor conditions
- LED indicators
- Operating Temperature: up to 50 Degree Celsius.
- Relative Humidity: 95%
- MCBF: Min 4,000,000 Cycles
- Power Supply: 240 Vac
- Same model shall be capable of expanding into "N" number of lanes.
- Approvals: NABL, CE, FDA, ROHS, FCC, ISO, QCI, NSIC, BS EN 60204-1:2018, EN 61000-6-2-2005, EN 61000-6-3:2007, EN ISO 12100:2010

Note: Successful bidder / Contractor shall be submitted the technical datasheets of above technical requirement in the form of Compliance document. No deviation shall be accepted.

1.4.19 Technical Specifications of Multi Zone Door Frame Metal Detector

S No	Specification of MZDFMD
1	Detection: (i) The system should be capable of detecting ferrous, non-ferrous and alloy metals concealed in the body of a person when passed through the archway. (ii) Uniform detection from top to bottom is required. (iii) Should be able to detect multiple metal objects of various weight, size and shape in all the zones simultaneously from head to toe.
2	Passage Dimension: (i) Height - Min 200mm (ii) Breadth - Min 720mm (iii) Width - Min 570mm
3	Speed of Passage: Performance of the DFMD should be independent of the speed of person passing through. This is particularly important as a person's foot may swing through the archway without touching the ground or may come to rest on the ground between the archway pillars.
4	Weight: 80 Kg maximum
5	Power supply: 100 - 260 VAC, 50 -60Hz, 12-24 VDC, should be provided with internal battery backup for 6 hours minimum in operational condition.

S No	Specification of MZDFMD
6	Alarm indication: (i) There should be Acoustic and Optical alarm with alphanumeric display, height on person bar display (Metal locator) and low battery indication. (ii) There should be a provision for suitable setting for adjustment of volume of the audible alarm to overcome the ambient noise present in the vicinity.
7	Sensitivity & Zones: (i) Dual side detection (ii) 18 overlapping detector multi-zones (iii) Displaying panel (iv) Indication of alarm areas (v) Adjustable area of sensitivity (vi) Two Way operation (vii) Static counting (Directional Counter - In, Out, Net and Alarm)
9	Calibration: DFMD shall have inbuilt feature of both manual and automatic calibration.
10	Security: (i) There should be a provision to secure the access to the control unit by a password protected alpha numeric keypad. (ii) DFMD should reset itself within 3 Sec after alarm condition. (iii) Unit should have traffic and alarm counter. The equipment should work in bidirectional mode.
11	Other features: (i) High discrimination between small masses and personal metallic objects. (ii) Automatic synchronization for DFMDs located close to each other up to a distance of one feet side by side.
12	Static Metal Compensation: DFMD installed closed to fixed sheet or pieces of metal, which form part of the building or its fittings. The DFMD should compensate for the presence of such metal and its performance should not be degraded by the presence of metal as stated above.
13	Health and Safety: (i) Magnetic field should be harmless to magnetic media, electronic devices and should be film safe, (Supplier shall submit test certificates from national/international accredited lab). (ii) Operation of DFMD shall not be affected by infrared, ultraviolet, electromagnetic or RF radiation. Offered equipment shall comply with CE or equivalent safety/ immunity standard (Supplier shall submit test certificates from national/international accredited lab). (iii) DFMD should be harmless to pacemaker and pregnant woman (Supplier shall submit test certificates from national/international accredited lab as per ICNIRP guidelines).
14	Interference rejection: (i) Interference, which is 'mains-borne' or radiated by an external source, should not cause the DFMD to raise the alarm spuriously. It should be

S No	Specification of MZDFMD
	possible to use equipment such as radio, portable telephone, walkie-talkie sets, X-ray monitors etc. at a distance of one mtr from the archway without causing spurious alarms. (ii) Moving metal beyond one mtr from DFMD should not affect performance of the DFMD. It should be possible to move metallic items like trolleys, metallic gate opening /closing one mtr away from the DFMD without the generation of false alarm.
15	Operating Temperature: DFMD shall work satisfactorily without any deterioration in performance within the temperature range of -20 to +55 °C, RH up to 90% non-condensing.
16	Accessories to provide: (i) Operating manual for the user. (ii) Standard Test Piece (STP) for testing of equipment to be provided by the supplier with each equipment. Optional Should have a ruggedized Polypropylene shock proof container for safe transportation of product compliant to IP-65 and Latest Mil Std. (As per requirement of the user).

Note: Successful bidder / Contractor shall be submitted the technical datasheets of above technical requirement in the form of Compliance document. No deviation shall be accepted.

1.4.20 Technical Specifications for X-Ray Baggage Machine

Tunnel Size - Minimum 600mm W (width) x Minimum 400mm H (Height) or better.
Conveyor best speed should be between 0.18 and 0.3 meter per second Conveyor movement bidirectional.
All machines should operate on 230 VAC. 50 KZ power supply and should be able to withstand voltage fluctuations in the range of 170V to 260 V. Single Phase. 3 to 5 Amp.
Conveyor Capacity -160 kg or more
Through put should be 200 bags per hour or more
Sensors > 1000 diodes, L-shaped detector (Folded array type), in case of defective diode arrays, scanning should be disabled, and error message should be displayed on the screen.
X-Ray Voltage - Maximum 160 XV
X-Ray Source/Generator - It should be capable to operate smoothly for a period j of at least six years.
Duty Cycle- 100%
The X-ray beam divergence should be such that the complete image at j maximum size of bag is displayed without corner cuts.
The radiation level should not exceed accepted health standard (0.1m R/Hr at a distance of 5 CM from external housing). Relevant certificate from AERB.
The operating temperature normally should be 0 deg C to 40 deg C.
Storage temperature 0 degree C to 50-degree C.
Humidity- 90% non-condensing

Resolution: The machine should be able to display single un-insulated tinned copper wire of 38-AWG. All penetration and resolution condition should be met without pressing any functional key and should be online.
Penetration should be 35 mm thickness of steel or more.
Continuous Electronic Zoom facility should be available to magnify the chosen area of an image eight times (8X) or more. Image features shall be keyboard controllable.
Video display- 18.5" or better LCD Monitor SVGA High resolution, low radiation, flicker free, resolution at least 1280 x 1024, 24-bit colour real time processing.
The machine should have features of Multi-energy X-ray imaging facility where materials of different atomic number will be displayed in different colors to distinguish between organic and inorganic materials. With this method to distinguish high density organic materials including explosives. Machine should have variable colour or materials stripping to facilitate the operator to monitor! images of organic materials for <i>closer</i> scrutiny. All suspicious items (Explosives, High density, material narcotics) should be displayed in one mode and that j should be online
Radiation Safety: The machine must comply with requirements of health and safety regulations with regard to mechanical electrical and radiation hazards. Before installation of the machine, the supplier/manufacturer should furnish relevant certificate from Atomic Energy Regulatory Board of India regarding radiation safety. The company manufacturing the equipment should have ISO certification for manufacturing and servicing of X-ray Screening machines.
Film - Safety Guaranteed safety for high-speed films up to ISO1600. The machines should be film safe. In other words, photographic films must not be damaged due to X-Ray examination.
Machine should be properly sealed from all the sides for pest proof. Dust proof cover is to be provided for covering when system is not in use.
Facility for variable contrast must be incorporated to allow enhancement of lighter and darker portion of the image.
The machine should be so designed that software enhancement can be easily implemented to take care of new technique in image processing and pattern recognition.
Full diagnostic built in test facility. All models should have software-controlled diagnosis report facility and system should give printout if printer is connected.
All software features of machine should be online, and password protected.
Machine should-be capable for recalling 15 or more previous images.
It should have the capability of archiving 3000 or more images with date & time stamp.
Control desk with security housing and locking provision should be available. The operator personal identification number can be entered the keyboard along with generation of log.
Facility of image enhancement should be available.
All models should have online recording facility and images can be recorded in CD R/W or/and USB and should be able to view images so recorded on stand-alone PC.
Lead impregnated safety screens should be available at either ends of the tunnel. This should be covered by relevant AERB certificate. Idle rollers to be provided at either ends of the tunnel to facilitate placing of baggage at input and output.

All software features should be controlled from keyboard of machine only. Keyboard function should be user friendly. To enable/disable the software features system should not be rebooted
If the machine fails to penetrate a particular item, then an alarm video and audio both should be generated to notify the operator
The threat image projection (TIP) system software to be incorporated in all X- Ray BIS operation as per details given in Annexure-I.
Copy of all software including X-Ray Software with recovery CD must be provided.
Operational Training- Operating staff has to be provided free training.
Operating & service manual shall be provided with each machine.
Other Features a) Edge &. variable edge enhancement. b) Inverse Video c) Set up time not more than 10 minutes d) Pseudo colour e) Date & Time display.
Minimum Computer Configuration: - Dual Core Processor at min 3.6 GHz, 8GB RAM, 4TB Hard disk, With Wired Mouse & Customized Keyboard with Emergency stop function, Linux OS, DVD Writer. 10/100/1000 on board integrated Network Port with remote booting facility remote system installation, remote wake up, cut of band management using any standard management software.
UPS: - 3 KVA or better online with back-up time of 1/2 hour to whole system.
Threat image Projection
Tip software facility shall be incorporated in the offered X-ray machine to assist supervisors in testing the operator alertness and training X-ray screeners to improve their ability in identifying specific threat object. The system will create a threat object and the same will be superimposed on the monitor screen while a bag is being screened. To acknowledge that the operator has seen the false object, operator must press the control panel key that will cause the computer-generated threat object to disappear from x-rayed bag image on the VDU screen. Each operator's action shall be recorded in the hard disc of the computer for the auditing purpose by the supervisor or other authorized person.
Design of the System:
Tip software should be compatible with other X-ray technologies such as automatic reject unit. Dual X-Ray screen technologies, automatic treat recognition system etc. All x-ray image functions must be available at the same time along with the TIP.
Image Library
The image library should have an image library containing at least 100 explosives devices. 100 knives and 100 firearms in various sizes, shapes, locations, and orientations. However, the system shall have facility to expand the library to incorporate additional images by user without assistance of the manufacture.
The image library should contain images of threats at different orientations both plan and end on orientation should be used. Although these will be assigned different file names and references, it must be possible to cross-reference these as the same threat All threat image Projection images must be realistic, representative, and non-distinguishable from real threat items.

Time Interval
Programming facility shall be available to project threat images in different intervals. The time period for threat image as well as image mix in percentage shall be user programmable e.g., software shall select 40% images of explosive devices, 35% of firearms & 25% knives or random etc.
Once the screener has responded to identify the computer-generated threat image, it should remain on the screen for a predefined user programmatic feedback message shall be visible to the screener.
System Administration
The threat image projection facility shall have <i>details</i> of user database such as Department name, screener name, Organization, User ID Number, level of access such screener, administrator Maintenance & Password etc.
Access to start up menu should be restricted only to the authorized individuals. A log-in procedure by means of Password" or "Security Key" could achieve restricted access to each of the comment. The log-in procedure should not take longer than 20 seconds. The system should have facility to bypass the TIP facility, if programmed so by the system administrator. It is to be ensured that the TIP software shall not be hindrance to normal functioning of x-ray machines.
When the operator logs-in or logs-out message should be displayed on x-ray BIS VDU Screen to confirm that the/she has been correctly toggled-in or logged- out.
Feedback Report
The threat image Projection should be capable of giving feedback "HIT, MISS or FALSE ALARM" message. No message will be presented if a screener correctly passed as clear bag.
A "HIT" message to be presented when a screener has correctly identified a Threat image Projection Image. A "MISS": message shall be presented when screener fails to identify the Tip image. A "False Alarm" message shall be given when screener incorrectly indicate TIP image when in fact no threat image projection is present. The feedback should clearly Indicate in a screen that a tip object has been correctly identified/tip object has been missed/ that a TIP object has been missed/no TIP object was present. Information should be recorded in the database.
Different colour coding shall be used for feedback to the Screener., It is recommended that colour code "Red for MISS" Green for "HIT" and Yellow to False Alarm or interrupt" be used.
The system shall automatically prepare the daily log of events for each shift and for each Screener performance. TIP log shall include particulars of Name of Screener, Time & date of threat image, weather threat image was successfully identified or missed etc.
The report on Threat Image Projection system may have date and time (From - to) as per requirement. Screener particulars, and decision/outcome i.e., MISS, HIT or False Alarm in percentage as well in absolute numbers, numbers of bags screened, categories such as explosives devices knife or weapon etc.
As a standard practice, daily/weekly /monthly report shall be retrieved. Report shall be for any given time and period, as per command.
All data should be stored on the system for a minimum of two months after it has been downloaded No individual, regardless of access rights to the Threat Image Projection components would delete or amend any of threat image Projection data or

time i.e., Threat Image Projection data on the actual X-ray machine will be read only file.

Note: Successful bidder / Contractor shall be submitted the technical datasheets of above technical requirement in the form of Compliance document. No deviation shall be accepted.

1.4.21 Technical Specifications for Under Vehicle Scanning System

Required Technical Parameters to be complied
The housing material of UVSS Area Scan must be CARBON STEEL with SS finish.
The camera used should be Area scan camera and the images captured should not have any distortion while scanning the vehicle fast, slow, halting during scanning.
The system should use dual area scan camera to capture left composite image and right composite images.
The images captures should stitch/morph in the software and should provide 3D view
The dimensions of the UVSS shall be in the range of 1500 L x 500 W x 150 H (in mm); However, Dimension shall be as per the OEM specified subject to complying the other technical parameters.
The UVSS and underground cameras should be enclosed in a suitable all-weather-proof housing of IP 67 or higher standard.
The UVSS should be capable of handling vehicles moving at different speeds ranging from Zero (0) to 40 kmph forward and reverse from zero (0) to 16 kmph while the composite images captured by the system should be automatically and dynamically adjusted according to the speed of the vehicle.
The overall installed unit should be properly designed, and its structure should be able to withstand a total vehicle load of min of 35 tons or higher at any given point over the structure, more particularly at the centre of the unit, so as not to suffer any accidental physical damage to the unit.
The UVSS scanning limit should not be less than in the range of: a) Height: 50-1500mm. b) Width: 4000mm. c) Length: 8000mm
The angle of view should be between 160° ~ 170°.
The image scanned should have a feature to view in both black & white and in colour with a resolution of a minimum of 4MP.
The power supply for the UVSS should be 24V DC, 3A, and LED power supply 24V DC, 320W.
The weight of the scanner should be between 70 ~ 80 kgs.
The system should be able to process and read number plates of vehicles with a speed of 40 km/hr or higher speed
The system should activate the license plate video capture cameras when the vehicle approaches.
The system should store video clips of the vehicle approaching the location.
The system processing should be real time i.e., instant recognition of license number plates.
The system shall automatically detect the license plate in the captured video feed in real time.

Required Technical Parameters to be complied
The capture rate of the UVSS should be greater or equivalent to 99.1%.
The operating temperature of the UVSS should be between -10°C to 60°C
The transfer interface or the distance should be Gigabit Ethernet / 100m.
The captured or scanned image should be in real-time and must be displayed in the software of the UVSS.
The UVSS should be capable of scanning with different chassis heights and ultra-long vehicles.
The UVSS should be embedded with bi-directional triggers for bi-directional scanning.
The UVSS portable area scan should have a Central Monitoring Systems feature to be available for remote viewing.
The UVSS should have a bi-directional LPR function that should capture and recognize both the front and rear license plates of the vehicle.
There should be no limit restriction of the vehicle chassis length that can be scanned by the UVSS.
There should be a feature that automatically turns on the fill light to enhance the output of the chassis increasing the quality of the image when viewed in the UI.
The design of the under vehicle scanning system should have a PITLESS design that shall allow for easy maintenance and accommodating all weather conditions.
the scanning unit should be designed with floor mounted body to have a depth of not more than 100mm to avoid pits in the roads.
It should be minimum of 10 versatile image processing functions to identify the suspicious more effectively.
There should be a feature that automatically adjusts the brightness of the output image of the chassis picture captured.
The control box supplied should be compact and kept inside the security room. a) Dimension: As per the OEM Specified b) POE: 8 ports 10/100/1000M RJ45 c) POE standard: IEEE802.3af/at d) ETH: 1 port 10/100/1000M RJ45 e) External trigger: 2 Channel f) Power Supply: AC 220V g) Weight: As per the OEM Specified and same shall be mounted at Block wall.
The scanning unit should use dual LED linear lights for dual camera array consecutively.
The scanning unit should not use any sort of Halogen or CFL-type lighting elements for the purpose of illumination.
The UVSS system must possess the capability to capture an exceptionally high-resolution, comprehensive composite underbody image of any vehicle passing over it. This should be achieved seamlessly using a dual high-resolution area scan GigE IP camera, all without necessitating the vehicle to come to a stop.
The image scanned should have a feature to view in both black & white and in colour with a resolution minimum of 4MP stored in the database.
The UVSS should be able to adjust the brightness and contrast of the composite image dynamically and automatically, to ensure good quality images, irrespective of different external lighting conditions.

Required Technical Parameters to be complied	
The UVSS must have a feature to compare the (Current and past) images to get more clarity on the changes if any done or harmful items carried in the chassis.	
The captured or scanned image should be in real-time and must be displayed in the software of the UVSS.	
There should be multiple ISP functions and the scanned images should be viewed with options of Brightness, Contrast, Sharpness, Saturation, White balance, Reset, and Foreign Object Detection level.	
The UVSS must have an automatic exposure adjustment, which helps to have a clear output by adjusting the brightness of the image true picture of the chassis is captured.	
The software should permit the operator to edit or correct the license plate number manually on the GUI after cross-checking the overview image or physical inspection of the license plate in case the license plate number captured is incorrect due deformed license plate or so.	
The software should be able to recognize any type of Indian standard number plate in English.	
The software of UVSS should be easy to access and have quick retrieval of images/ snapshots, video, and other data for post-incident analysis and investigations.	
The software should have a feature that enables search option facility of license plates from the database.	
The UVSS software should have a real-time output of the composite images, driver images, front image of the vehicle, and license plate in the monitor instantly.	
The UVSS system should have a facility to back up all the data from the database to any storage or backup device.	
The UVSS should have a provision to integrate with the Boom Barrier & Bollard.	

1.4.22 Technical Specifications for Boom Barrier

Technical Parameters	Technical Parameters to be complied
Model of the Arm	3 Meters & 1.5 Meters Telescopic Arm with Red Reflective Strips
Power Supply	220V/110 V +-10%
Operating Temperature	-10°C to 60°C
Housing Dimension	330(Width) x 239.5(Depth) x 931.5(Height) mm
Motor Power consumption	60 W
Frequency	50HZ
LED Light	Display on the front panel
Barrier Weight excluding Boom Barrier	≤ 50 kgs
Maximum Remote-Control Distance	≥ 30 m
Sensor	Dual Eye Photo Sensor Cells
Control	DC motor, 24 V
Access Control	Integration with access control system provision

Technical Parameters	Technical Parameters to be complied
Parking Management System	Integration with parking management system provision
Voltage Fluctuation	Inbuilt Capacitor
Power Distribution System	Single Phase Power Distribution
Internal Spring	100% Duty Cycle Dual Spring
Protective earthing	Should be Provided
PCB Board	Dual Capacitor
Protection from electric shocks and energy hazards	Fully Protected. No access to hazardous parts
Lubrications	No lubrication required for internal motors
Wireless Remote control	2 Numbers
Push button for manual operation	1 Number
Minimum Cycles Before Failure (MCBF)	10 million Cycles
Certifications	ISO, NABL, CE, FDA, RoHS, QCI, NSIC, FCC

1.4.23 Way Finder application:

- Way finder comes with a 55" interactive display comes with a stand that is suitable to position it in any environment. The installation shall be done by Contractor.
- The features of the application will be as follows:
 - Pedestal prebuilt mountable stand.
 - Application will have user-friendliness without knowledge on coding.
 - Integration and dynamic data fetched from current CRP application.
 - Live Editing capabilities of customer or client data.
 - Information directory: Find details through keyword search
 - Amenities directory: Find facilities by category and name.
 - Capability to scan and go using mobile app via mobile browser.
 - Ability to work without internet.
 - Work off-line and sync with server once the connection is restored.
 - Ability to promote a product or company to generate additional revenue or pass general information to visitors.
 - Facility to change destination names, logos, descriptions, and promotions.
 - Interactive facility like touch, zoom and rotate functionality will be made within the limits of the interactive display capabilities.
 - Integration with CRP.
 - View on mobile with QR Scan.

1.4.24 Specification of Perimeter Intrusion Detection System (PIDS)

- Generally, all the sites shall have Boundary wall with grill / Chain link mesh / Welded mesh / Wall top razor fence, CGI etc, to protect their premises from intrusion. Any type of intrusion at with said premises will not give any indication to the User. CSCS can be installed on any type of premises and provide indication to the User upon intrusion with an accuracy of less than 3 meters. PIDS can easily be integrated to other electronic gadgets like CCTV / Access Control Systems or third-party monitoring software.

- PIDS is the best possible solution for Intrusion detection upon intruder breaching and suitable for all types of security fencing.
- The following Features to be considered and the product in which selected from the approved make list shall be a proven technology in the Indian Market and the same is available in the market at least 15 years.
 - Excellent detection resolution of less than 3 meters
 - Fully electronic with no moving parts in the sensor
 - User defined perimeter Zone length
 - Unlimited perimeter Zones
 - Microcontroller based indigenously developed technology
 - Easily expandable
 - Alarm generation at Control room
 - Programmable Sensitivity to meet site requirements using Software
 - Integration can be carried out with the help of Potential Free Contacts in the field or at Control room using standard I/O devices
 - Mounting of Sensors can be carried out on Walls with metal structure over it / Mesh / Concertina coil / Wire or any similar surfaces
 - PIDS Software will control & monitor all field Node controllers and Sensors.
 - Any intrusion will be detected and alarm indication along with its location will be displayed on the PC screen.
 - No false alarm will be raised against any type of heavy vehicular traffic / heavy machinery / strong winds etc.
 - Zones shall be allotted based on the location of Cameras or as per User requirements
 - User friendly and flexible to meet stringent site conditions
- **Environmental conditions for PIDS equipment**
 - Operating temperature: - 10°C to 60°C
 - Humidity: 0 to 100% non-condensing
 - UV protection
 - Rainfall: Up to 25 mm / hour
 - Snowfall: Up to 30 cm / hour
- **The functional Operational for PIDS**
 - Vibration Sensors (Transducer) which are placed at every 5 meters (recommended) over wall all along the proposed perimeter.
 - PIDS Control Unit which monitors all sensors connected to it. Sensor will detect the Vibrations created by the intruder while trespassing and the same is detected by respective PIDS Control Unit.
 - PIDS Control Unit is a Microcontroller based Software driven unit with inbuilt network controller which is used to connect to existing Fibre / LAN network for 2-way communication with Software.
 - Each unit can cover 500 meters (100 sensors) on either side and the quantity required depend on the total perimeter length to be covered. Any type of violation in the set parameters will be immediately detected and the data is communicated to PIDS Software located at Control room.
 - 4 core (Minimum) Shielded cable will be used for Input Power and Data Communication between the Transducers and Node controller. Communication protocol will be RS 485 and the input power will be supplied by PIDS Control Unit for all the connected Transducers.

- All the Node Controllers are in turn connected to existing LAN network thru onboard RJ45 connector. Any number of Node Controllers can be connected within the same network.
- Perimeter can be divided into any number of zones with flexibility on Zone length using PIDS Software.
- All types of False alarms including Wind, Trend, Heavy vehicular traffic etc are avoided by indigenously developed PIDS Software using Artificial Intelligence, Filters and Adaptive Technology.
- PIDS Software will detect the natural and abnormal activities which almost eliminate false Alarms and increases the intrusion detection capability.
- **PIDS Alarm Generation**
 - Climbing on the Wall / Mesh / Coil / Wire / Glass / Iron sheets etc
 - Applying pressure on security fencing
 - Moving or removing the Sensor or Sensor cable
 - Cutting / damaging of Cable
 - Tampering Node Controller
 - Loss of Communication from Node Controllers
 - Gate open alarm
 - Any other parameter in consultation with User (Optional)
- **PIDS Advantages**
 - Easy to install
 - Multiple sensing
 - Adjustable sensitivity sensor wise
 - Smart patrol with the help of a Magnetic stick.
 - Patrol log with date and time
 - Gate alarm
 - Tamper alarm
 - Configurable Extreme temperature alarm
 - Vibration alarm
 - Works with standard 12V DC
 - Creation of Unlimited number of zones
- **Specifications of Transducers**
 - Each sensor will convert the vibration signals into electronic data / signal and sent to respective PIDS Control Unit for processing in real time.
 - Every Sensor has a special address for communication and setting Sensor specific settings.
 - 0 to 3 Meter (Radius) detection
 - Contains vibration sensor
 - Weatherproof having a rating of IP67
 - Uniform detection over a wide range of frequency range to capture maximum vibrations from the Wall / fence
 - Power consumption: Less than 15 mW per Sensor.
 - Easy to fix on any surface either with UV rated cable ties or suitable hardware.
- **Specifications of PIDS Controller**
 - TCP/IP based communication from field to control room.
 - Inbuilt 8 /16 relay modules for providing Voltage Free contacts.
 - Micro Processor based Alarm processing unit with in-built TCP/IP.
 - Interfaces supported are TCP/IP.

- Power consumption: Less than 10 W.
- Operating voltage: 12V / 5V.
- Built in Data Storage.
- 12V DC Charger unit.
- **Requirement of PIDS Software:**
 - Monitor all PIDS Controller connected to its network.
 - Any number of Node control units can be connected to the Software.
 - Monitor and collect data from all field Sensors connected within its network
 - Will divide the perimeter into unlimited Zones as per the convenience of the User.
 - Algorithm based Filters to minimize nuisance alarm caused by Wind, Trend, Rainfall etc.
 - Indicate Alarm upon Intrusion, Cable cut, Communication loss with specific Node control unit.
 - Alarm wise Event logging, storing the data and facility to print the data.
 - Will have the facility to bypass any specific sensor(s) within the same network
 - Admin has all the rights to change the parameters, passwords etc.
 - Every User has specific password and User report will be generated accordingly
 - Any number of authorized Users can operate the system.
 - User will have limited access to the Software, and it will be decided by the admin
 - Zone scheduling for maintenance or any other similar purposes
 - API will be provided for Integration with other third-party gadgets.

1.4.25 Cables & Conduits

- All the cables shall be PVC insulated FRLS copper, multi strand, shielded cables shall be 650V grades and shall generally confirm to IS –1554 – 1988 and meet the signal cabling requirement of the system manufacturer.
- 4 x 1Sq.mm shall be used for Readers & EM Lock (Single Leaf Door) with Door Position Sensor. Door Position Sensor for Double Leaf Door.
- 2 x 1Sq.mm shall be used for EM Lock (Double Leaf Door), Door Position Sensor, Emergency Door Release & Door Buzzer. Cabling between UPS point to the Controllers etc., shall be in the scope of electrical contractor.
- 3 x 1.5Sq.mm Cable from Power point to Controller & Reader Modules.
- All the cables shall be laid in PVC Conduit. PVC conduit shall be FRLS Heavy duty pipes to be used.
- The PVC Conduit shall be FRLS (Heavy duty grade with 2mm thickness).
- The rate shall inclusive of all necessary fixing items, bends, coupler, junction box (2way, 3way, 4way), flexible hose pipe, screw, nut & bolts, clamps, etc to considered within the cost. No additional cost shall be provided.

1.4.26 Testing & Commissioning of Security System

General Requirements

- The contractor shall perform all tests submitted in the “Test Procedure” section as outlined in the specification.

- Provide a program for the testing and commissioning procedure. Use a qualified representative of the ACS supplier to co-ordinate testing and present at all tests and training courses and remain on-site until the ACS is fully operational.

Factory testing Procedure

- Submit procedure for factory test at least two weeks prior to the test. After test: Submit summary of results and necessary modifications.

Site testing and commissioning

- Carry out the following
 - Attendance at the testing of all equipment that interfaces to the ACS and confirmation of the operation of such equipment from the ACS interface terminals.
 - Testing of all field wiring from terminals to field interface terminal strips.
 - Testing and commissioning of all power supplies and batteries.
 - Verification of communication to remote systems.
- Testing of the operation of each control point from the operator's workstation (if supplied) and verification of the status of all points and alarm functions on graphic displays. Demonstrate the following
 - Operation of each control loop.
 - Globally transferred information such as alarms.
 - Detection and action of all alarm conditions.
 - Communications with PC workstations.
 - Time schedules and after-hours operation.
 - Mapping of system points to operator's workstation(s).
 - Operator's workstation software.
 - Power fails re-starts.
 - Essential power mode operation.
- Fire mode of operation.

Final acceptance Test

- After the testing report and as built drawings have been approved by the customer's representative, the completed system shall be tested in the presence of the customer's representative.
- Acceptance of the system shall require a demonstration of the stability of the system. Should major equipment failure occur, the contractor shall replace or repair component (s)
- Any other test those are required for checking the quality & performance of the system

1.5 IP CCTV Surveillance System**1.5.1 General Requirements**

The Closed-Circuit Television System (CCTV system) shall provide an on-line display of video images on monitor. Cameras with suitable lenses shall be used to view specific areas of interest. The primary objective of implementing a CCTV system is to ensure effective surveillance of an area and create a record for post event analysis.

The CCTV System shall comprise of:

- AI Based IP Cameras
- CCTV Servers, NAS
- Video Management Application & Server
- Video Analytics Application and Server

Equipment of CCTV System

The CCTV System shall comprise of

- Dome Cameras,
- Multi directional camera,
- Bullet cameras,
- PTZ cameras,
- Monitoring Stations,
- Video Management Application & Server
- Video Analytics Application and Server

1.5.2 Technical Specification of Artificial Intelligent IP Cameras

5MP Dome IR Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Image Sensor	1/2.8" progressive scan RGB CMOS or better	
Day/ Night Operation	Yes, with IR Cut Filter	
Minimum Illumination	Color: 0.07Lux (F1.6, 1/30sec, 30IRE) BW: 0.007Lux (F1.6, 1/30sec, 30IRE), 0Lux (IR LED on)	
Lens	3.2~10.2 mm (3.2x) motorized varifocals (+/-1mm) or better	
Electronic Shutter	1 to 1/10,000sec with preferred shutter control or better	
Image Resolution	5MP or better	
Compression	H.264/H.265 Main, Baseline, High Profiles	
Frame Rate and Bit Rate	30 fps with Controllable bit rate, frame rate and Maximum Bit rate	
Video Streams	Minimum 3 Nos, individually configurable streams in H.265 @ 5MP at 30 frame rate	
Motion Detection	Yes, built in with multiple configurable areas in the video stream.	
Audio	two-way Support	
Audio Compression	G.726(ADPCM) 8KHz, G.711 8KHz G.726: 16Kbps, 24Kbps, 32Kbps, 40Kbps AAC-LC: 48Kbps at 16KHz	
Image Enhancement	Built in WDR, BLC, Barrel Distortion/ Lens Distortion	
Wide Dynamic Range	Upto 120 dB or better	
IR	30 Meter (Built in or External) IR	
Alarm & Audio Connectors	1 Input & 1 Output for Alarm & Audio Interface	

5MP Dome IR Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Analytics	Object type: Person, Face, Vehicle Analytics events based on AI engine: Object detection, Virtual line Crossing, Loitering, Intrusion Analytics events: Defocus detection, Virtual area (Appear/Disappear)) Motion detection, Tampering The Video Analytics shall be built in availability in Camera itself or 3 rd party analytics software and server shall be considered in case the camera OEM does not have built in available as mentioned analytics features without any additional cost.	
Event Actions	File upload(image): e-mail/FTP - Notification: e-mail - Recording: SD/SDHC/SDXC or NAS recording at event triggers - Alarm output - Handover (PTZ preset, Send message by HTTP/HTTPS/TCP) - Audio clip playback	
Edge Storage Capacity	256 GB or Better	
Protocols	IPv4, IPv6, TCP/IP, UDP/IP, RTP(UDP), RTP(TCP), RTCP, RTSP, NTP, HTTP, HTTPS, SSL/TLS, DHCP, FTP, SMTP, ICMP, IGMP, SNMPv1/v2c/v3(MIB-2), ARP, DNS, DDNS, QoS, UPnP, Bonjour, LLDP, CDP, SRTP (TCP, UDP Unicast)	
OS / Firmware Protect	Secure boot, Signed firmware, Firmware encryption	
Data Protect	Authentication information encryption, ZIP compression encryption, SD card partition encrypt	
Security	Digest Authentication, Prevent brute- force attack, 802.1X Authentication (EAP-TLS, EAP-LEAP, EAP-PEAP MSCHAPv2), HTTPS, SRTP, WSS (WebSocket secure), Access control based on IP address, User Access/System/Event log management, Secure by default	

5MP Dome IR Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Firmware Upgrade	The firmware upgrade shall be done through web interface, The firmware shall be available free of cost	
Interface	RJ-45(10/100BASE-T) or better	
Memory	2GB RAM, 1GB Flash or better	
Application Programmers Interface	The interface shall be available for integration with 3rd party analytics and applications in public domain	
Lens Type	DC auto iris (IR corrected)	
Mount	Wall Mount/ Pole Mount	
Compatibility	ONVIF Profile S, G, T, M	
Enclosure	IP66, IK10 or better The camera and housing shall be of same make of camera	
Power requirements	Vendor to specify, POE Preferred	
Operating Temperature	-20 °C to 55 °C	
Operating Humidity	Max 90% RH or better	
Certificate	FCC 47 CFR 15 Subpart B Class A ICES-3(A)/NMB-3(A) CE/UKCA - EN 55032 Class A, EN 50130-4, EN 61000-3-2, EN 61000-3-3 VCCI CISPR 32 Class A RCM AS/NZS CISPR 32 Class A, UL 62368-1, CAN/CSA C22.2 NO. 62368-1 IEC/EN 62471, IEC/EN 63000 IEC/EN 60529 IP66, IEC/EN 62262 IK10, NDAA	
HEVC Certificate	The camera OEM Should have valid H.265 HEVC Certificate and should be listed on HEVC website at the time of submitting bid. OEM should be paying the licensing fee for using the genuine HVEC Compression legally. The confirmation document of same needs to be submitted with bid & will also be checked on following official website https://accessadvance.com/hevc-advance-patent-pool-licensees/	
MAC Address	MAC ids of the quoted products shall be provided by OEM and MAC address of the proposed equipment must be registered in name of OEM.	

5MP Dome IR Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
General	1. The Intellectual Property Rights of equipment (Camera and VMS) must not reside in China. The equipment supplied should not be manufactured by an entity in which the majority shareholding of the entity is from China.	
	2. Any of the proposed item/equipment should not contain Chinese make chipsets/Soc/sensor/parts. Camera OEM needs to submit declaration on letterhead regarding quoted model specific sensor and SoC details (make, model etc.)	
	3. OEM Needs to confirm that the proposed item/equipment shall not be installed with restricted GB/T standards/protocols and there shall be no option in camera settings to activate/deactivate such standard/protocol which allow bypassing of all security parameters.	

5MP Bullet IR Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Image Sensor	1/2.8" progressive scan RGB CMOS or better	
Day/ Night Operation	Yes, with IR Cut Filter	
Minimum Illumination	Color: 0.07Lux (F1.6, 1/30sec, 30IRE) BW: 0.007Lux (F1.6, 1/30sec, 30IRE), 0Lux (IR LED on)	
Lens	3.2~10.2 mm (3.2x) motorized varifocals (+/-1mm) or better	
Electronic Shutter	1 to 1/10,000sec with preferred shutter control or better	
Image Resolution	5MP or better	
Compression	H.264/H.265 Main, Baseline, High Profiles	
Frame Rate and Bit Rate	30 fps with Controllable bit rate, frame rate and Maximum Bit rate	

5MP Bullet IR Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Video Streams	Minimum 3 Nos, individually configurable streams in H.265 @ 5MP at 30 frame rate	
Motion Detection	Yes, built in with multiple configurable areas in the video stream.	
Audio	two-way Support	
Audio Compression	G.726(ADPCM) 8KHz, G.711 8KHz G.726: 16Kbps, 24Kbps, 32Kbps, 40Kbps AAC-LC: 48Kbps at 16KHz	
Image Enhancement	Built in WDR, BLC, Barrel Distortion/ Lens Distortion	
Wide Dynamic Range	Upto 120 dB or better	
IR	30 Meter (Built in or External) IR	
Alarm & Audio Connectors	1 Input & 1 Output for Alarm & Audio Interface	
Analytics	Object type: Person, Face, Vehicle Analytics events based on AI engine: Object detection, Virtual line Crossing, Loitering, Intrusion Analytics events: Defocus detection, Virtual area (Appear/Disappear) Motion detection, Tampering The Video Analytics shall be built in availability in Camera itself or 3 rd party analytics software and server shall be considered in case the camera OEM does not have built in available as mentioned analytics features without any additional cost.	
Event Actions	File upload(image): - e-mail/FTP - Notification: e-mail - Recording: SD/SDHC/SDXC or NAS recording at event triggers - Alarm output - Handover (PTZ preset, Send message by HTTP / HTTPS / TCP) - Audio clip playback	
Edge Storage Capacity	256 GB or Better	
Protocols	IPv4, IPv6, TCP/IP, UDP/IP, RTP(UDP), RTP(TCP), RTCP, RTSP, NTP, HTTP, HTTPS, SSL/TLS, DHCP, FTP, SMTP, ICMP, IGMP,	

5MP Bullet IR Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
	SNMPv1/v2c/v3(MIB-2), ARP, DNS, DDNS, QoS, UPnP, Bonjour, LLDP, CDP, SRTP (TCP, UDP Unicast)	
OS / Firmware Protect	Secure boot, Signed firmware, Firmware encryption	
Data Protect	Authentication information encryption, ZIP compression encryption, SD card partition encrypt	
Security	Digest Authentication, Prevent brute-force attack, 802.1X Authentication (EAP-TLS, EAP-LEAP, EAP-PEAP MSCHAPv2), HTTPS, SRTP, WSS (WebSocket secure), Access control based on IP address, User Access/System/Event log management, Secure by default	
Firmware Upgrade	The firmware upgrade shall be done through web interface, The firmware shall be available free of cost	
Interface	RJ-45(10/100BASE-T) or better	
Memory	2GB RAM, 1GB Flash or better	
Application Programmers Interface	The interface shall be available for integration with 3rd party analytics and applications in public domain	
Lens Type	DC auto iris (IR corrected)	
Mount	Wall Mount/ Pole Mount	
Compatibility	ONVIF Profile S, G, T, M	
Enclosure	IP66, IK10 or better. The camera and housing shall be of same make of camera	
Power requirements	Vendor to specify, POE Preferred	
Operating Temperature	-20 °C to 55 °C	
Operating Humidity	Max 90% RH or better	
Certificate	FCC 47 CFR 15 Subpart B Class A ICES-3(A)/NMB-3(A), CE / UKCA EN 55032 Class A, EN 50130-4, EN 61000-3-2, EN 61000-3-3, VCCI CISPR 32 Class A, RCM AS/NZS CISPR 32 Class A, UL 62368-1, CAN/CSA C22.2 NO. 62368-1 IEC/EN 62471, IEC/EN 63000 IEC/EN 60529 IP66, IEC/EN 62262 IK10. NDAA	

5MP Bullet IR Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
HEVC Certificate	The camera OEM Should have valid H.265 HEVC Certificate and should be listed on HEVC website at the time of submitting bid. OEM should be paying the licensing fee for using the genuine HVEC Compression legally. The confirmation document of same needs to be submitted with bid & will also be checked on following official website https://accessadvance.com/hevc-advance-patent-pool-licensees/	
MAC Address	MAC ids of the quoted products shall be provided by OEM and MAC address of the proposed equipment must be registered in name of OEM.	
General	1. The Intellectual Property Rights of equipment (Camera and VMS) must not reside in China. The equipment supplied should not be manufactured by an entity in which the majority shareholding of the entity is from China.	
	2. Any of the proposed item/equipment should not contain Chinese make chipsets/Soc/sensor/parts. Camera OEM needs to submit declaration on letterhead regarding quoted model specific sensor and SoC details (make, model etc.)	
	3. OEM Needs to confirm that the proposed item/equipment shall not be installed with restricted GB/T standards/protocols and there shall be no option in camera settings to activate/deactivate such standard/protocol which allow bypassing of all security parameters.	

5MP PTZ IR Outdoor Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Image Sensor	1/2.8" Progressive Scan CMOS or better	

5MP PTZ IR Outdoor Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Day/ Night Operation	Automatic with IR Cut Filter	
Minimum Illumination	Color: 0.1Lux (F1.6, 1/30sec) BW: 0Lux (IR LED On) IR: Built in or External IR upto 200 Meters or better	
high-speed pan-tilt functionality	360° endless pan range and -20 to 90° tilt range or better	
Optical Zoom	30 x optical zoom Minimum & 12 x Digital Zoom or better Lens with focal length Corresponding to 30x zoom	
Pan, tilt, manual and preset speed. The speed shall be applicable for Manual, Tour, and Preset Mode	Pan Speed - 500°/s, Manual: 0.024°/sec ~ 250°/sec and Tilt Speed Preset: 350°/sec, Manual: 0.024°/sec~250°/sec or better	
Image Resolution	5MP or better	
Compression	H.265 Baseline, Main and High Profiles or better	
Frame Rate and Bit Rate	Upto 30 fps with Controllable bit rate, frame rate and Maximum Bit rate	
Video Streams	Minimum 3 Nos, individually configurable simultaneous streams in H.265 @ 8MP at 30 Fps or better	
Motion Detection	8 Polygonal zones	
Electronic Shutter	1/10 to 1/10,000sec or better	
Electronic Exposure & Control	Automatic/ Manual	
Wide Dynamic Range	120 dB or better	
Backlight & Highlight Compensation	Built in, Required	
Electronic Image Stabilization	Built-in gyro sensor, Required	
Privacy Masks	Minimum 32 configurable zones or better	
Preset Positions	Minimum 300 or better	
Image Flip	Yes Automatic	
Built In Heater & FAN	Required	
Audio	Two Way with Classification, built in or external, Optional	
Alarm Triggers	Analytics, Network disconnect, Alarm input, Time schedule, MQTT subscription	
On-screen directional indicator	Required	

5MP PTZ IR Outdoor Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Analytics	Object type: Person, Face, Vehicle Analytics events based on AI engine: Object detection, Virtual line Crossing, Loitering, Intrusion Analytics events: Defocus detection, Virtual area (Appear/Disappear)) Motion detection, Tampering The Video Analytics shall be built in availability in Camera itself or 3 rd party analytics software and server shall be considered in case the camera OEM does not have built in available as mentioned analytics features without any additional cost.	
Auto Tracking Analytics	Object auto tracking (Person/Vehicle) & Target lock tracking	
Event Actions	File upload(image): e-mail/FTP, Notification: e-mail, Recording: SD/SDHC/SDXC or NAS recording at event triggers, Handover: PTZ preset, send message by HTTP/HTTPS/TCP, MQTT: publication, Alarm output / Audio clip playback	
Edge Storage Capacity	1TB Support, Class 10 Type SD card	
Protocols	IPv4, IPv6, TCP/IP, UDP/IP, RTP(UDP), RTP(TCP), RTCP, RTSP, NTP, HTTP, HTTPS, SSL/TLS, DHCP, FTP, SMTP, ICMP, IGMP, SNMPv1/v2c/v3(MIB-2), ARP, DNS, DDNS, QoS, UPnP, Bonjour, LLDP, CDP, SRTP (TCP, UDP Unicast), NTCIP1205, MQTT	
Water Removal	Built in Wiper required	
Security	Digest Authentication, Prevent brute- force attack, 802.1X Authentication (EAP-TLS, EAP-LEAP, EAP-PEAP MSCHAPv2), HTTPS, SRTP, WSS (Web socket secure), Access control based on IP address, Authentication information encryption, ZIP compression encryption, User	

5MP PTZ IR Outdoor Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
	Access/System/Event log management,	
OS / Firmware Protect	Secure boot, Signed firmware, Firmware encryption	
Interface	RJ 45, 100 Base TX or better	
Enclosure	IP66, IK10, NEMA 4x, Nema-TS or better The camera and housing shall be of same make of camera	
Mount	Wall / Pole Mount	
Secure Storage	TPM (Trusted platform module) with FIPS 140-2 level 2, SD card partition encrypt	
Operating Temperature	-20 °C to 50 °C with Maximum temperature upto 70°C based on NEMA TS-2or better	
Operating Humidity	Max 90% RH or better	
Memory	4GB RAM, 512 MB Flash or better	
Certification	FCC 47 CFR 15 Subpart B Class A, ICES-3(A)/NMB-3(A), CE/UKCA, EN 55032 Class A, EN 50130-4 VCCI CISPR 32 Class A, RCM AS/NZS CISPR 32 Class A, KS C 9832 Class A, KS C 9835, UL 62368-1, CAN/CSA C22.2 NO. 62368-1 IEC 62471, EN IEC 63000, IEC 60529 IP66, IEC 62262 IK10 NEMA TS 2-2013 (2.2.7, 2.2.8, 2.2.9), NEMA 250 type 4X, NDAA	
Embedded Applications	The camera shall provide a platform allowing the upload of third-party applications into the camera	
Application Programmers Interface	1. The interface shall be available for integration with 3rd party analytics and applications in public domain 2. Onvif S, G, T, M or better	
HEVC Certificate	The camera OEM Should have valid H.265 HEVC Certificate and should be listed on HEVC website at the time of submitting bid. OEM should be paying the licensing fee for using the genuine HVEC Compression legally. The confirmation document of same needs to be submitted with bid & will also be	

5MP PTZ IR Outdoor Vandal-Proof Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
	checked on following official website https://accessadvance.com/hevc-advance-patent-pool-licensees/	
MAC Address	MAC ids of the quoted products shall be provided by OEM and MAC address of the proposed equipment must be registered in name of OEM.	
General	1. The Intellectual Property Rights of equipment (Camera and VMS) must not reside in China. The equipment supplied should not be manufactured by an entity in which the majority shareholding of the entity is from China.	
	2. Any of the proposed item/equipment should not contain Chinese make chipsets/Soc/sensor/parts. Camera OEM needs to submit declaration on letterhead regarding quoted model specific sensor and SoC details (make, model etc.)	
	3. OEM Needs to confirm that the proposed item/equipment shall not be installed with restricted GB/T standards/protocols and there shall be no option in camera settings to activate/deactivate such standard/protocol which allow bypassing of all security parameters.	

Multi Sensor Camera (2MP x 4 Sensor Camera)		
Description	Technical Compliance Parameter	Compliance Yes / No
Image Sensor	~ 4 x 1/2.8" Progressive Scan CMOS or better	
Day/ Night Operation	Automatic with IR Cut Filter	
Minimum Illumination	Color: 0.1Lux (F1.5, 1/30sec, 30IRE) BW: 0.01Lux (F1.5, 1/30sec, 30IRE), 0Lux (IR LED on) IR: Built in or External IR upto 20 Meters or better	
Pan/ Tilt/ Rotate	0°~360° / 0°~65° / 0°~90°: Manual or remote adjustment	

Multi Sensor Camera (2MP x 4 Sensor Camera)		
Description	Technical Compliance Parameter	Compliance Yes / No
Lens	3.3~5.7mm (1.7 to 2 x) motorized varifocal (+/-1 mm) or better	
Image Resolution	1920x1080 per sensor or better	
Compression	H.264/H.265 Baseline, Main and High Profiles	
Frame Rate and Bit Rate	Upto 25 fps with Controllable bit rate, frame rate and Maximum Bit rate	
Video Streams	Minimum 3 Nos, individually configurable streams in H.265 @ 8MP at 20 frame rate	
Motion Detection	Yes, built in with multiple configurable areas	
Electronic Shutter	1 to 1/12,000sec or better	
Wide Dynamic Range	120 dB or Better	
Backlight & Highlight Compensation	Built in, Required	
Lens Distortion Correction	Built in, Required	
Privacy Masks	Minimum 10 configurable zones or better	
Image Flip	Yes Automatic	
Audio	Two Way, built in or external, required	
Alarm	2 Input/ Output Ports or better	
Event Triggers	Object type: Person, Face, Vehicle Analytics events based on AI engine: Object detection, Virtual line Crossing, Loitering, Intrusion Analytics events: Defocus detection, Virtual area (Appear/Disappear)) Motion detection, Tampering The Video Analytics shall be built in availability in Camera itself or 3 rd party analytics software and server shall be considered in case the camera OEM does not have built in available as mentioned analytics features without any additional cost.	
Event Actions	File upload(image): e-mail/FTP, Notification: e-mail, Recording: SD/SDHC/SDXC or NAS recording at event triggers, Alarm output, Handover: PTZ preset, send message by HTTP/HTTPS/TCP, Audio clip playback, MQTT: publication	

Multi Sensor Camera (2MP x 4 Sensor Camera)		
Description	Technical Compliance Parameter	Compliance Yes / No
Edge Storage Capacity	1 TB or Better	
Protocols	IPv4, IPv6, TCP/IP, UDP/IP, RTP(UDP), RTP(TCP), RTCP, RTSP, NTP, HTTP, HTTPS, SSL/TLS, DHCP, FTP, SMTP, ICMP, IGMP, SNMPv1/v2c/v3(MIB-2), ARP, DNS, DDNS, QoS, UPnP, Bonjour, LLDP, SRTP (TCP, UDP Unicast), MQTT	
OS / Firmware Protect	Secure boot, Signed firmware, Firmware encryption	
Security	Digest Authentication, Prevent brute-force attack, 802.1X Authentication (EAP-TLS, EAP-LEAP, EAP-PEAP MSCHAPv2), HTTPS, SRTP, WSS (WebSocket secure), IP address filtering, Authentication information encryption, ZIP compression encryption, User Access/System/Event log.	
Secure Storage	TPM 2.0 with FIPS 140-2 level2	
Interface	RJ-45(10/100/1000BASE-T) or better	
Enclosure	IP66, IK10 and NEMA 4X rated or better	
Mount	Wall / Pole Mount	
Audio Compression	G.711 u-law /G.726 Selectable, G.726(ADPCM) 8KHz, G.711 8KHz G.726: 16Kbps, 24Kbps, 32Kbps, 40Kbps, AAC-LC: 48Kbps at 16KHz	
Operating Temperature	-20 °C to 55 °C or better	
Operating Humidity	Max 90% RH or better	
Memory	8GB RAM, 1GB Flash or better	
Certification	FCC 47 CFR 15 Subpart B Class A, ICES-3(A)/NMB-3(A) CE/UKCA, EN 55032 Class A, EN 50130-4, EN 61000-3-2, EN 61000-3-3, VCCI CISPR 32 Class A, RCM AS/NZS CISPR 32 Class A, KS C 9832 Class A, KS C 9835, UL 62368-1, CAN/CSA C22.2 NO. 62368-1, IEC/EN 62471, IEC/EN 63000, IEC/EN 60529 IP66, IEC/EN 62262 IK10, NEMA 250 type 4X. NDAA	

Multi Sensor Camera (2MP x 4 Sensor Camera)		
Description	Technical Compliance Parameter	Compliance Yes / No
HEVC Certificate	The camera OEM Should have valid H.265 HEVC Certificate and should be listed on HEVC website at the time of submitting bid. OEM should be paying the licensing fee for using the genuine HVEC Compression legally. The confirmation document of same needs to be submitted with bid & will also be checked on following official website https://accessadvance.com/hevc-advance-patent-pool-licensees/	
MAC Address	MAC ids of the quoted products shall be provided by OEM and MAC address of the proposed equipment must be registered in name of OEM.	
General	1. The Intellectual Property Rights of equipment (Camera and VMS) must not reside in China. The equipment supplied should not be manufactured by an entity in which the majority shareholding of the entity is from China.	
	2. Any of the proposed item/equipment should not contain Chinese make chipsets/Soc/sensor/parts. Camera OEM needs to submit declaration on letterhead regarding quoted model specific sensor and SoC details (make, model etc.)	
	3. OEM Needs to confirm that the proposed item/equipment shall not be installed with restricted GB/T standards/protocols and there shall be no option in camera settings to activate/deactivate such standard/protocol which allow bypassing of all security parameters.	

Automatic Number Plate Recognition (ANPR) Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Image Sensor	1/3" progressive scan RGB CMOS or better	
Day/ Night Operation	Yes, with IR Cut Filter	

Automatic Number Plate Recognition (ANPR) Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Minimum Illumination	Color: 0.5 lux; B/W 0 Lux with IR	
Lens	6 - 60 mm (+/- 1mm), IR corrected, Megapixel Lens with Motorized zoom and autofocus or better	
Electronic Shutter	1 to 1/10,000sec with preferred shutter control or better	
Image Resolution	1920 x 1080 or better	
Compression	H.264/H.265 Main, Baseline, High Profiles	
Frame Rate and Bit Rate	Upto 120 fps with Controllable bit rate, frame rate and Maximum Bit rate	
Video Streams	Minimum 3 Nos, individually configurable streams @ H.265, full resolution, full frame rate	
Motion Detection	Yes, built in with multiple configurable areas in the video stream.	
Defog	Support: Built in or software based. In case of software based additional server shall be considered	
Electronic Image Stabilization	Built in Required	
Image Enhancement	Built in WDR, BLC, Barrel Distortion/ Lens Distortion	
Pre-sets	255	
Pan Tilt Zoom	Digital PTZ	
Wide Dynamic Range	Upto 150 dB or better	
IR	85 Meter (Built in or External) IR	
Alarm & Audio Connectors	1 Input & 1 Output for Alarm & Audio Interface	
Analytics	Analytics:- Defocus detection, Motion detection, Tampering, Fog detection, Audio detection, Sound classification, Shock detection, Virtual area (Appear/Disappear) AI Based Classified object type : Person/ Face/ Vehicle/ License plate AI Based Attributes : Vehicle (Type: car/ bus/ truck/ motorcycle) AI Analytics events - Object detection, Virtual line (Crossing/Direction), Virtual area (Loitering/Intrusion/Enter/Exit) The Video Analytics shall be built in availability in Camera itself or 3rd party analytics software and server shall be	

Automatic Number Plate Recognition (ANPR) Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
	considered in case the camera OEM does not have built in available as mentioned analytics features without any additional cost.	
Event Actions	When alarm trigger occurred - File upload(image): e-mail/FTP - Notification: e-mail - Recording: SD/SDHC/SDXC or NAS recording at event triggers, - Alarm output, - Handover: PTZ preset, send message by HTTP/HTTPS/TCP, - Audio clip playback, - MQTT: publication	
Edge Storage	1TB GB or Better	
Protocols	TCP/IP, UDP/IP, IPv4, IPv6, RTP(UDP), RTP(TCP), RTCP, RTSP, NTP, HTTP, HTTPS, SSL/TLS, DHCP, PPPoE, FTP, SMTP, ICMP, IGMP, SNMPv1/v2c/v3(MIB-2), ARP, DNS, DDNS, QoS, PIM-SM, UPnP, Bonjour	
Text Overlay	Date & time, and a customer-specific text, camera name, graphical image etc	
Security	TPM 2.0(FIPS 140-2 level 2) HTTPS(SSL) Login Authentication Digest Login Authentication IP Address Filtering User access log 802.1X Authentication (EAP-TLS, EAP-LEAP, EAP-PEAP MSCHAPv2) Device Certificate(Root CA, pre-installed) Secure by default certificate Secure OS/Boot/Storage, Verify firmware forgery	
Firmware Upgrade	The firmware upgrade shall be done though web interface, The firmware shall be available free of cost	
Interface	RJ 45, 100 Base TX or better	
Internal Memory	2GB RAM, 512 MB Flash or better	
Enclosure	IP67, IK10, NEMA 4x, NEMA-TS 2 or better The camera and housing shall be of same make of camera	

Automatic Number Plate Recognition (ANPR) Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
Power requirements	Vendor to specify, POE Preferred	
Operating Temperature	-20 °C to 55°C with Maximum temperature upto 70°C based on NEMA TS-2or better	
Operating Humidity	Max 90% RH or better	
Certification	UL, CE, FCC, BIS, NDAA	
Application Programmers Interface	The interface shall be available for integration with 3rd party analytics and applications in public domain	
Embedded Applications	The camera shall provide a platform allowing the upload of third-party applications into the camera	
Mount	Wall Mount/ Pole Mount	
Compatibility	ONVIF Profile S, G, T, M	
HEVC Certificate	The camera OEM Should have valid H.265 HEVC Certificate and should be listed on HEVC website at the time of submitting bid. OEM should be paying the licensing fee for using the genuine HEVC Compression legally. The confirmation document of same needs to be submitted with bid & will also be checked on following official website https://accessadvance.com/hevc-advance-patent-pool-licensees/	
MAC Address	MAC ids of the quoted products shall be provided by OEM and MAC address of the proposed equipment must be registered in name of OEM.	
General	1. The Intellectual Property Rights of equipment (Camera and VMS) must not reside in China. The equipment supplied should not be manufactured by an entity in which the majority shareholding of the entity is from China.	
	2. Any of the proposed item/equipment should not contain Chinese make chipsets/Soc/sensor/parts. Camera OEM needs to submit declaration on letterhead regarding quoted model specific sensor and SoC details (make, model etc.)	

Automatic Number Plate Recognition (ANPR) Camera		
Description	Technical Compliance Parameter	Compliance Yes / No
	3. OEM Needs to confirm that the proposed item/equipment shall not be installed with restricted GB/T standards/protocols and there shall be no option in camera settings to activate/deactivate such standard/protocol which allow bypassing of all security parameters.	

Conditional Compliance Notes for all type of tender required cameras

- All type of tender requirement cameras shall comply the following compliance with certification of approval of BIS, NDAA Compliant, Security Maturity Certificate, CVE or CVSS Score, Complete Report of Security Vulnerabilities & ULCAP Certification for approval of product. HTTPS (SSL) Login Authentication, Digest Login Authentication, IP Address Filtering, User access log, 802.1X Authentication (EAP-TLS, EAP-LEAP, EAP-PEAP MSCHAPv2), Secure by default certificate, Secure OS/Boot/Storage, Verify firmware forgery, Cyber Security assurance program UL CAP (UL 2900-1).
- Cameras shall not be complied with standards like - GB28181, GB/T28181 - 2011, GB / T 28181-2011, GBT 28181 - 2011, GBT28181 - 2011, GB/T28181 - 2016, etc., protocols / standards and there shall be no option in the camera web page / settings to activate or deactivate such protocols / standards any of their version(s).
- All above compliance along with technical requirement mentioned in the tender documents shall be complied without any deviation.

1.5.3 Specification for Network Joystick

Network Joystick for PTZ Camera		
a	Communication	
	Control Equipment	Network camera
	Interface	Ethernet (Network camera), USB
b	Interface protocol	
	Ethernet	supports
	USB	supports
	Units to control	Max. 255 network cameras, 1 SSM.
	Network Protocol	TCP, HTTP, DHCP, IPv4
c	Operational Mechanical	
	LCD Display	5-inch TFT LCD
	Joystick	3 axis twist zooms
d	Control	
	Camera	Pan/Tilt/Zoom, Focus, Auto focus, Preset, Group, Tour, Swing, Trace, Auto tracking, Alarm off/on, Freeze
	Recorder	Recording, playback control, alarm off, menu
	Device management	Built-in device registration, modification on LCD
	User management	admin + 9 operators

Network Joystick for PTZ Camera		
	Import, Export	Configuration import/export
e	Miscellaneous	
	Video snapshot	Still image (network camera) export using USB memory
	Input	Alphabet input (virtual keyboard)
	Environmental	
	Operating Temperature	0°C ~ 40°C (+32°F ~ +104°F)
	Operating Humidity	20 ~ 85%
	Electrical	
	Input voltage	12V DC
	Power consumption	Max. 6.4 W

Note: Successful bidder / Contractor shall be submitted the technical datasheets of above technical requirement of all type of cameras & joystick in the form of Compliance document. No deviation shall be accepted.

1.5.4 Power Requirements

- The camera shall be proposed with integral power supply (PoE and 12VDC Power Supply Jack Connector) with an in-built power supply module. However, all the cameras shall be energised through only PoE.
- The cameras shall be energised through POE. External power supply energizing will not be accepted. However, the cameras shall have PoE enablement as well power jack with inbuilt. The cameras shall comply with min IEEE 802.3af class 3 compliant
- It shall have a built-in encrypted Web server. It shall have a facility to have an audio input thro LAN from the camera if required.
- Min Operating Conditions
 - ✓ Temp: 5-50 °C (41-104 °F)
 - ✓ Humidity: 20-80% RHG
 - ✓ Motion detection, tamper alarm, backlight compensation & WDR features
- **Approvals**
 - ✓ EMC
 - ✓ FCC CFR Part 15 Class B
 - ✓ EN55022:1998 Class B
 - ✓ EN61000-3-2:2000
 - ✓ EN61000-3-3:1995
 - ✓ VCCI Class B
 - ✓ AS/NZS 3548
 - ✓ Safety:
 - ✓ EN60950 & EN 60950 – 1
 - ✓ BIS, NDAA Compliant
 - ✓ UL/ relevant European approvals
- The cameras shall also have dome enclosure with clear or smoked dome as required at site

1.5.5 Video Management Application (VMS) Requirements

- The VMS shall support ONVIF - industry standard for the interface of IP-based physical security products. The VMS shall provide ONVIF S & G Compliance in order to provide more advance features of cameras.
- The VMS Module shall allow the Direct configuration of IP camera device with no requirement to ever directly connect via web page of IP camera or encoder to configure these parameters.
- Discover on IP network and set IP Address, Frame Rate, Resolution, Motion detection: within camera or server based, Bit Rate, Key frame interval, Digital I/O, Audio Inputs/Outputs, Ability to update firmware of IP camera or encoder.
- Any configuration changes do not require the server services to be restarted.
- VMS Security Platform shall be compatible with both 32-bit and 64-bit operating systems including latest Windows 2022 support.
- The VMS shall be based on a true open architecture that shall allow for use of non-proprietary workstation and server hardware, non-proprietary network infrastructure and non-proprietary storage.
- The VMS shall offer a complete and scalable video surveillance solution which allows cameras to be added on a unit-by-unit basis.
- All video streams supplied from IP cameras shall be digitally encoded in H.264 / H.265 or better compression formats and recorded simultaneously in real time.
- The VMS shall support configuration of individually configurable multiple streams for Live & Recording. This functionality shall also support configuration of each camera stream separately. Altering the setting of one camera shall not affect the recording & display settings of other cameras.
- The VMS shall be able to use multiple CCTV keyboards to operate the entire set of cameras throughout the system, including cameras of various manufacturers' brands, including their PTZ functionalities.
- The VMS shall be able to retrieve and set the current position of PTZ cameras using XYZ coordinates.
- The Platform shall consist of a role-based architecture, with each Server hosting one or more roles.
- The System shall be managed by the central database role that contains all the system information and component configuration.
- The Database Management Role shall authenticate users and give access to the system based on predefined user access rights or privileges, and security partition settings.
- The Database Management Role shall support the configuration of camera units, PTZ functionalities. Camera sequences, recording schedules.
- The Video Recording Role shall be responsible for managing cameras and encoders under its control and archiving video.
- The system shall have a routing role responsible for routing video and audio streams across the networks from the source to destination.
- The system shall have Health Monitoring Role for monitoring and logging health events and warnings from the various client applications, roles, and services that are part of the Security Platform The role shall also log events within the Windows Event Log, generating reports on health statistics and health history.

- The Surveillance User Interface shall be able to use for monitoring of video from the cameras, events & alarms, Interface shall also facilitate the recorded video.
- The user interface shall provide control & monitor of IP network.
- User Interface shall facilitate the control of Pan Tilt & Zoom functionality and pre-sets of the PTZ cameras.
- User Interface shall also facilitate the control of iris and focus of the camera.
- User Interface shall be possible to perform digital zooming on the live as well as playback video.
- User Interface shall allow administrators and operators with appropriate privileges to monitor, run reports and manage alarms.
- The User Interface shall support following to enhance usability and operator efficiency such as
 - Dynamically adaptive interface that adjusts in real-time to what the operator is doing.
 - A dynamic dashboard loaded with entity-specific widgets, e.g., camera widget.
 - Use of transparent overlays that can display multiple data in a seamless fashion.
 - Display tile menus and quick commands.
 - Consolidated and consistent workflows.
 - Tile menus and quick commands easily accessible within every display tile of the user workspace.
- The User Interface shall have task-based approach for monitoring of video & alarm monitoring.
- User Interface shall have task for investigation of video bookmark, smart motion search, archive reports, audit trails and activity reporting.
- User Interface shall support a sequence of operations an operator or administrator shall execute to complete an activity. The “flow” relates to a clearly defined timeline or sequence for executing the activity.
- The user shall have full control over the user workspace through a variety of user-selectable customization options. Administrators shall also be able to limit what users and operators can modify in their workspace through privileges.
- Once customized, the user shall be able to save his workspace.
- The user workspace shall be accessible by a specific user from any client application on the network.
- Display tile patterns shall be customizable.
- Event or alarm lists shall span anywhere from a portion of the screen up to the entire screen and shall be resizable by the user. The length of event or alarm lists shall be user-defined. Scroll bars shall enable the user to navigate through lengthy lists of events and alarms.
- The User Interface shall support multiple display tile patterns, e.g. 1 display tile (1x1 matrix), 16 tiles (8x8 matrix), and multiple additional variations.
- The User Interface shall support as many monitors as the PC video adapters and Windows Operating System are capable of accepting.
- The User Interface shall display of all cameras attached to the system.
- Shall support live video monitoring on each and every display tile within a task in the user's workspace.
- The operator shall be able to drag and drop a camera into a display tile for live viewing.

- The operator shall be able to drag and drop a camera from a map into a display tile for live viewing.
- The User Interface shall allow operators to bookmark important events for later retrieval on any archiving camera. Operators can uniquely name each bookmark in order to facilitate future searches.
- The operator shall be able to start/stop recording on any camera in the system, which is configured to allow manual recording, by clicking on a single button.
- The operator shall be able to switch one or more video tile to switch for instant replay. This operation shall not affect live monitoring of other cameras.
- Users shall be able to take snapshots of live video and be able to save or print the snapshots.
- The Server Monitoring Service shall be installed on all PCs/servers running with security platform software. In the event of a malfunction or failure, the Server Monitoring Service shall restart the failed service. As a last resort, the Server Monitoring Service shall reboot the server/PC if it unable to restart the service.
- The Platform shall support the Alarm Management functionality. The User shall have the ability to acknowledge alarms, create an incident upon alarm acknowledgement, and put an alarm to snooze. The user shall be able to spontaneously trigger alarms based on something he or she sees in the system.
- The Surveillance User interface's video playback capabilities shall include:
 - Shall support audio and video playback of any time span.
 - Shall support video playback on each and every display tile.
 - Shall allow operators to switch to instant replay of the video for any archiving camera with the simple click of button.
 - Shall allow the operator to select between instant synch of all video streams in playback mode allowing operators to view events from multiple angles or across several camera fields, or non-synchronous playback.
 - Shall allow the operator to simultaneously view the same camera in multiple tiles at different time intervals.
- Shall allow the operator to control the playback with:
 - Pause, Lock Speed.
 - Forward and Reverse Playback at: 1x, 2x, 4x, 6x, 8x, 10x, 20x, 40x, 100x.
 - Forward and Reverse Playback frame by frame
 - Slow Forward and Reverse Playback at: 1/8x, 1/4x, 1/3x, 1/2x.
 - Loop playback between two-time markers
 - Shall display a single timeline, or optionally one timeline for each selected video stream, with which the operator can navigate through the video sequence by simply clicking on any point in the timeline.
 - Shall display the level of motion at any point on a timeline.
 - Shall clearly display bookmarks events on the timeline(s).
 - Shall be able to query archived video using various search criteria, including but not limited to, time, date, camera, and area, among others.
 - Shall provide the tool to search video and associated audio on user-defined events or motion parameters.
 - Shall allow operators to define an area of the video field in which to search for motion as well as define the amount of motion that shall trigger search results.The Surveillance User Interface shall then retrieve all archived video streams

which contain motion which meets the search parameters. There shall be a graphical timeline where the time of each search hit shall be indicated.

- Shall allow operators to browse through a list of all bookmarks created on the system and select any bookmarked event for viewing.
- Shall allow the user to add bookmarks to previously archived video for easier searching and retrieval.
- Shall support digital zoom on playback video streams.
- Shall provide still image export to PNG, JPEG, GIF, and BMP format with Date and Time stamp and Camera Name on the image (snapshot).
- Shall provide tools to export video on various media such as a CD-ROM.
- Shall allow operators to load previously exported video files from their computer or network.
- Shall allow queries to be saved upon closing the Archive Player Application and reappear when the application is reopened.
- The Security Platform shall permit the user to select multiple entities to monitor from the Surveillance User Interface by adding the entities one by one to the tracking list.
- The Surveillance User Interface shall provide the option to filter which events shall be displayed in the display tile layout and/or event list layout.
- It shall also be possible to lock the display tile so that it only tracks the activity of a specific entity.
- The user shall be permitted to start or pause the viewing of events within each display tile.
- The Interface shall support the ability to manually track a moving target with the single click of a button.
- The ability to switch from one camera view to an adjacent camera shall be done within a single display tile.
- Switching between camera streams shall be accomplished by simply clicking on the transparent overlay.
- Visual tracking shall be available with both live and recorded video.
- The user interface monitoring client shall be able to take control of other client station based on the privilege level and control the tile of the other client like a video wall application.
- **Cyber security certification for VMS**
 - The software shall incorporate stronger security of security mechanism to prevent vulnerabilities, man-in-the-middle attack by providing digital certificate-based authentication between server to server & server to clients. The VMS shall have achieved UL 2900-2-3 Level 3 Cyber security certification.
- **Dashboards**
 - The USP shall support the ability to create multiple dashboards. Operators shall be allowed to view respective dashboards depending on user rights. A dashboard shall consist of a canvas with various widgets displayed on the canvas. All widgets should offer the ability to specify location and size to the widget, a title to the widget, a background colour to the widget, and the ability to refresh periodically the content of the widget. Dashboard widget types shall be:
 - ✓ Image: provides the ability to display an image (JPG, PNG, GIF, BMP) on a dashboard.

- ✓ Text: provides the ability to display a text on a dashboard. The text style shall be configurable, so font, size, colour, and alignment can be specified by the user.
- ✓ Tile: provides the ability to display any entity of the USP inside of a tile.
- ✓ Web page: provides the ability to display a URL on a dashboard.
- ✓ Entity Count: provides the ability to display the total number of a specific entity type in the USP.
- ✓ Reports: provides the ability to display the results of any saved reports in the system. The results shall be displayed either by showing the total number of results in the report, a set of top results from the report, or a visual graph from the data returned by the report.
- The USP shall support the following actions on a dashboard:
 - ✓ Print dashboard, export dashboard to PNG file, and automatically email a report based on a schedule and a list of one or more recipients.
- **Configuration User Interface**
 - The Configuration User Interface shall allow the administrator or users with appropriate privileges to change video configuration. It shall provide the ability to change video quality, bandwidth, and frame rate parameters on a per camera (stream) basis for both live and recorded video. It shall provide the ability to configure brightness, contrast, and hue settings for each camera on the same.
 - The Configuration user interface shall provide the capability to enable & change audio parameters, audio recording serial port configuration, I/O configuration on camera device units.
 - The Configuration User Interface shall provide the ability to set recording schedules and modes for each individual camera.
 - The recording mode shall be Continuous, on motion, manual only, Disabled.
 - The Configuration User Interface shall support the creation of schedules to which any of the following functional aspects can be attached:
 - ✓ Video quality (for each video stream per camera)
 - ✓ Recording (for each camera)
 - ✓ Motion detection (for each detection zone per camera)
 - ✓ Brightness, Contrast, Hue (for each camera)
 - ✓ Camera sequence execution
 - ✓ The Configuration User Interface shall support creation of unlimited recording schedules and assign any camera to any schedules.
 - **Network Attached Storage / Network Server Storage - NAS**
 - ✓ The NAS (Recording role) shall use an event and timestamp database for advanced search of audio/video archives. This database shall be Microsoft SQL 2012 or SQL 2014 or SQL 2019
 - ✓ The NAS shall digitally sign recorded video using 248-bit RSA public/private key cryptography.
 - ✓ The NAS shall offer a plug and play type hardware discovery service with the following functionalities:
 - ✓ The NAS shall have the capacity to configure the key frame interval (I-frame) in seconds or number of frames.

- ✓ The NAS shall support configuration of pre-alarm and post-alarm recording option that can be set between one second and 5 minutes on a per camera basis.
- ✓ The NAS shall support minimum 500 cameras or 1000 Mbps of recording throughput whichever comes first in case the network is ended to end multicast.
- ✓ The NAS shall support “unit level motion detection” as well as “software level motion detection”.
- ✓ Software level motion detection shall be able to divide camera field of view in 6 detection zone for setting up individual motion setting in each zone and trigger an event for each zone separately.
- ✓ The NAS shall have the capacity to communicate with Camera device using 128 bits SSL encryption.
- ✓ The NAS shall have the capacity to communicate with camera device using HTTPS secure protocol.
- ✓ The NAS shall have the capacity to receive multicast UDP streams directly from the camera unit.
- ✓ For network topologies that restrict the camera device from sending multicast UDP streams, the NAS shall redirect audio/video streams to active viewing clients on the network using multicast UDP.
- ✓ The NAS shall have the capacity to redirect audio/video stream to active viewing clients on the network using unicast UDP or TCP.
- ✓ The user interface of the monitoring station shall support dynamically switch the Live stream from – High Resolution, Low Resolution & Live (normal). This switching shall happen based on the resolution of monitoring tile & closest stream configuration.
- ✓ The NAS shall offer to set retention period for archive video for preset number of days. It shall also delete oldest video data if the disk is full before the retention time occurs.
- ✓ The NAS shall allow important video sequences to be protected against normal disk clean-up routines.
- ✓ The NAS shall keep a log and compile statistics on disk space usage.
- ✓ The NAS shall have the capacity to down-sample video streams for storage saving purposes.
- ✓ The NAS shall support camera unit with edge recording capabilities and offer the following capacity:
 - ✓ The ability to playback at different speeds the video recorded on the Camera device.
 - ✓ The ability to offload the video on schedule, on event or manually the video recorded on the camera device to store it on the NAS.
 - ✓ It shall be possible to filter the video that is being offloaded using one or multiple of the following filters:
 - ✓ Time interval, Playback request, Video analytic events, Motion events, Bookmarks, Alarms.
 - ✓ The NAS shall support analytics events received from camera unit having capability of edge analytics
- ✓ VMS shall support Bandwidth Control to for Live view and Playback stream to the clients.

- ✓ It shall be possible to configure number of concurrent live and playback stream allows.
- ✓ It shall be also possible to control the overall combined bandwidth in kbps
- ✓ It shall be possible to limit the bandwidth consumed by live and playback video from the client software to better control the bandwidth across multiple sites. The Server software shall be able to prioritize video streaming to the client based on user level.
- ✓ VMS shall have SQL Database info log like Event Count, Source Count, Video file count, Size on disk. VMS shall have provision to set notification for Diskspace and Database usage goes set value, VMS shall support the backup of SQL database from VMS GUI console.
- ✓ VMS client shall show on live stream about routing information like unicast, multicast or streaming from recording server
- ✓ VMS should support Dual sign in to log in to the system administrator and client - Log in shall be permitted when two authorized persons login. any user can login first and second user will authenticate. There shall be no restriction which user login first or second.
- ✓ VMS shall support auto lock of client after specified time with inactivity.
- ✓ VMS shall support able to give alarm if specified user is login in, log off.
- ✓ VMS shall support able to give alarm if specified user is login failed.
- ✓ VMS shall support following password management policies
- ✓ Admin shall create the user and set the password shall have provision to change the password on next login of user
- ✓ Admin shall have provision to set the user password rule like enforce minimum characters, uppercase, lower case, numerical character, special character.
- ✓ Admin shall set the password which can expire with specified time limit
- ✓ There shall be possible to lock user based on schedule decided by administrator
- ✓ VMS shall provide recommendations relating to the passwords used to access the hardware units in the system. The recommendation should display if the passwords used on the units are weak, average, strong, or very strong.
- **Mobile client:**
 - ✓ VMS shall support mobile client in android and iOS
 - ✓ VMS shall support Mozilla, Edge, Chrome browser-based web client
 - ✓ VMS shall support Maps, Alarms and Threat level activation support in Mobile client
- **Remote control Client:**
 - ✓ It shall be possible to admin user group client can control remotely operator group workstations client and able to see the full screen in its own GUI console.
 - ✓ This remote-control user client rights shall be configurable
- **Video Analytics Application**
 - ✓ Video Analytics system both as a primary detection system for operational alert use and as an approved event-based recording system for sterile zone monitoring applications.
 - ✓ User interfaces shall be available in English languages

- ✓ Real-time scene analysis and alarms based on user definable rules
- ✓ Powerful onsite or remote configuration capabilities
- ✓ Rich set of detectable events and behaviours to suit a broad set of system requirements
- ✓ Accurate indoor and outdoor applications with patented technology to reduce false alarms
- ✓ High performance software that minimizes the need for excessive PC hardware
- ✓ Improved Forensics Tool with Smart Search for instantaneous retrieval of incidents even under new rules. The list AI Based Analytics to be a part of this tender.
 - ❖ Video Motion Detection
 - ❖ Loitering
 - ❖ Tamper Detection Alarm
 - ❖ Object Tracking
 - ❖ Virtual Line Crossing
 - ❖ Facial Recognition
 - ❖ Masked / Covered Face Identification
 - ❖ People Counting
 - ❖ Automatic Number Plate Recognition
 - ❖ Vehicle Identification
 - ❖ Forensic search engine for Appearance / Disappearance

Note: The contractor shall consider the Edge based analytics as mentioned above. However, the Facial Recognition, Automatic Number Plate Recognition & People Counting shall be considered as Server based analytics to be considered.

1.5.6 Technical Specifications of Video Management System & Main Recording Server

Technical Parameters	Technical Description	Compliance Yes / No
Network Camera	400 Camera Channels	
Supported Resolution	Upto 12MP or better in each Channel	
PROCESSOR	Min Intel Xeon Processor E3-1275 v6 (3.8Ghz)	
MEMORY	a. 16GB ECC Memory DDR4 PC-17000 or better in each Box if 128 CH b. 32GB ECC Memory DDR4 PC-17000 or better in each Box if 256 CH	
RAID	Host Raid Controller Onboard Raid 0, 1, 5, 6	
DISPLAY PORT	VGA x 1, DVI x 1, HDMI x 1	
OS	Windows 10 IoT Enterprise	
NETWORK	Gigabit Ethernet RJ-45 (1000 Base-T) x4 (2 ports on board, 2 ports on the Additional NIC	

Technical Parameters	Technical Description	Compliance Yes / No
Storage Capacity	a. Upto 240TB or better. Min 16 Bay port or better, HDD Supports upto 24TB and 12Gb/s external storage support in each Storage Box if 128 CH b. Upto 360TB or better. Min 16 Bay port or better, HDD Supports upto 24TB and 12Gb/s external storage support in each Storage Box if 256 CH	
Onvif	Support required	
Live Display	Via workstation. However, 400 Channel to visualized in single screen by single workstation. Visualization by Multiple workstations shall not be accepted.	
Video Codec	H.264, H.265 or better	
VMS	Embedded	
Server Clustering	Server Clustering up-to Max 10,000 channels	
Live Monitoring and Playback	Available in same page	
Search	Object classification & Event based, Calendar / Event / Bookmark / Smart Support	
Recording Bandwidth	512 Mbps or better	
Operating System	Windows/ Linux	
Playback	Fast/Slow Forward/Backward, Move one step up/down	
Recording Mode	Normal, Schedule (Continuous / Event), Event (Pre / Post), Event profile	
Security	Encrypt recorded videos. Playback of any physically stolen videos will not be available providing confidentiality of recorded videos. Furthermore, as playback can only be done in a device with particular device certificate, integrity of data is also provided. AES256 is used for encrypting videos giving industry standard level of encryption.	
Dashboard	Dashboard provides the current information of all servers and devices. The overall information of system is shown including server and device status, network bandwidth and HDD usage. It also gives system event statistics for efficient management	

Technical Parameters	Technical Description	Compliance Yes / No
Event	Video loss, Camera event (Sensor, MD, Passing, Entering, Exiting, Disappearing (Appearing), Tampering, Tracking, Face Detection, Audio Detection) and object classification	
Bookmark	Bookmarks are used to identify and easily navigate to important recordings.	
Event Trigger	Instant Viewer, Preset, Alarm Out, Pop-up, Sound and E-mail notification	
Backup	AVI, backup with watermark & password, Manual backup, Onetime schedule backup	
Masking	Supports live masking feature to protect personal privacy.	
Audio	G.711 u-law (PCM), G723, G726 (ADPCM), AAC, Bidirectional for all channels	
Camera Setup	Auto/ Manual	
Camera Features	Automatic device IP scan, Profile edits, Resolution, Fisheye dewarping, Hallway/ Corridor view, Brightness / Contrast, Device setup page, Exporting / Importing devices settings, Device firmware update	
Date & Time Sync	NTP server	
PTZ	Control Device Via GUI, Controller, Preset	
Redundancy	N + 1 Support required (Active & Active, Active -Standby)	
Auto backup from SD card	Supported to recover footage saved in the camera. The footage saved in the SD card is protected during network disruptions.	
DDNS	Support required	
IPv4, IPv6	Support required	
Language	English	
Network	RJ-45 (1000 Base-T) x2	
Power Supply	230VAC 50 Hz	
Dual Power Supply	Dual Power support 100~240 VAC	
Operating Temperature / Humidity	+5°C ~ +40°C	
Certification	CE, BIS	

*****Technical Requirement of Video Recording Selection**

- **Storage calculation For Recoding Server** - 45days/25FPS @ 2MP/1080p FHD resolution and the rate shall inclusive of this line item. Software Generated Storage Calculation Sheet shall be furnished by Camera OEM and the same shall be submitted for approval. Maximum 100 Cameras in each Server if the server does have a Maximum of 128 Channel and Maximum 200 Cameras in each Server if

the server does have a Maximum of 256 Channel. The Server shall have 512 Channel Camera interface with 400 Cameras on-board Storage retention as mentioned above by using Surveillance Hard Disk Drive (HDD) with Minimum of 7200 RPM or more. Cost shall inclusive of all Recording Servers and its camera licenses, and its Video Storage Box (HDD) as mentioned the above configuration.

1.5.7 CCTV Monitoring station LED screen

Screen Size (inch, measured diagonally)	42 inches
Wi-Fi Standard	Wi-Fi Certified 802.11a/b/g/n/ac
WI-FI FREQUENCY	2.4 GHz/5 GHz (for Wi-Fi Direct: 2.4 GHz Only)
Bluetooth profile support	Version 4.2, HID (mouse / keyboard connectivity) / HOGP (Low Energy device connectivity) / SPP (Serial Port Profile) / A2DP (stereo audio) /AVRCP (AV remote control)
RF (Terrestrial / Cable) Connection Input(s)	1(Side)
Composite Video Input(s)	Hybrid with S-Centre Speaker Input x1 (Side, Mini jack)
HDMI inputs total	4 (4 Side)
HDCP	HDCP2.3 (for HDMI 1/2/3/4)
Features specified in HDMI2.1	4K120/ eARC /VRR/ALLM
HDMI Audio Return Channel (ARC)	Yes (eARC / ARC)
Variable Refresh Rate (VRR)	Yes (for HDMI 3/4)
Auto Low Latency Mode (ALLM)	Yes (for HDMI 3/4)
Digital Audio Output(s)	1(Side)
Headphone Output(s)	1(Side)
USB ports	2 (Side)
USB drive format support	FAT16/FAT32/exFAT/NTFS
USB playback codecs	MPEG1: MPEG1/MPEG2PS:MPEG2/MPEG2TS (HDV, AVCHD): MPEG2, AVC/MP4 (XAVC S): AVC, MPEG4, HEVC/AVI: Xvid, MotionJpeg/ASF (WMV): VC1/MOV: AVC, MPEG4, MotionJpeg/MKV: Xvid, AVC, MPEG4, VP8.HEVC/WEBM: VP8/3GPP: MPEG4, AVC/MP3/ASF WMA)/LPCM/WAV/MP4AAC/FLAC/JPEG, WEBM: VP9/AC4/ogg/AAC/ARW (Screen nail only)
Display resolution (H x V, pixels)	3,840 x 2,160
Backlight type	Direct (Full Array LED)
Backlight dimming type	Local Dimming
PANEL REFRESH RATE	100 Hz
HDR (High Dynamic Range) compatibility	Yes (HDR10, HLG, Dolby Vision)
Picture processor	Cognitive Processor XR

Clarity enhancement	XR 4K Upscaling
Video signal support	HDMI™ signal: 4096 x 2160p (24, 50, 60 Hz), 3840 x 2160p (24, 25, 30, 50, 60, 100, 120 Hz), 1080p (24, 30, 50, 60, 100, 120 Hz), 1080i (50, 60 Hz), 720p (24, 30, 50, 60 Hz), 576p, 480p
Picture modes	Vivid, Standard, Cinema, IMAX Enhanced, Game, Graphics, Photo, Custom, Dolby Vision (Vivid/Bright/Dark), Netflix calibrated, BRAVIA CORE calibrated
SENSOR	Light
Audio Power Output	10 W + 10 W + 5 W + 5 W
Sound modes	Standard, Dialog, Cinema, Music, Sports, Dolby Audio
ACOUSTIC CENTRE SYNC	Yes (Sony-compatible Soundbar)
Headphone 3D Surround Ready	Yes (with WLA-NS7)
Operating System	Android TV / iOS TV
SMART TV	Google TV / Apple TV
On-board Storage (GB)	32 GB
ECO DASHBOARD	Yes
Voice Search	(Voice Search) Yes/(Built-in Mic)Yes
BUILT-IN MIC SWITCH	Yes
Electronic Programmed Guide (EPG)	Yes
Internet Browser	Yes
Application Store	Yes (Google Play Store)
On/Off Timer	Yes
Sleep Timer	Yes

Note: The display shall be mounted 3 x 2 matrix and the output to be connected with Server / Client / CCTV Monitor Station. Multi-functional Display allocation controller and its Software cost shall be added in the CCTV Monitoring station cost itself. There will not pay any additional cost by the Employer if any hardware shall be required to facilitate the complete solution. Only one Output directly driven from the CCTV Operator Workstation to configure the 4 Display panel shall be utilised for CCTV monitoring and Other 2 Display shall be facilitated for Fire Alarm System Event Monitoring & BMS Trend Monitoring through respective Operator Workstation via the Display Controller. Accordingly, the Video Controller and its software shall be selected by Bidders. No additional cost shall be provided if will require to comply the above requirement.

1.5.8 CCTV Operator Workstation

Intel core 9th Generation Intel Core i9 Processor by latest generation or better, 16GB DDR3 RAM, 64-bit operating system, 1TB SSD for OS and Security Center applications, with a minimum of 16 GB of free disk space to install the Security Center client application, 1TB SATA Hard disk with 7200rpm, GbE network interface card, DVD-RW standard keyboard & Mouse with Dual NVIDIA® GeForce® RTX 2080 video card with 21" 4K / UHD LED MONITOR. Minimum 4 HDMI, 1 parallel, 8 USB 2.0, 1 serial, 2 Ultra ATA/100, 2 optional IEEE1394, 1 USB Keyboard, 1 USB Mouse, 1 video, 1 Microphone jack, 1 Line-in jack, 2 x 1GBPS RJ-45 Interface Port

Note: The Configuration mentioned is only Minimum requirement. Vendor to consider as per OEM recommendations in case of higher configurations shall be required as per project functional requirements and the bidder to consider the cost for the same & quote accordingly. The bidder needs to consider the same configuration if OEM will not have an objection for the mentioned specifications. No deviation shall be accepted.

1.5.9 Camera Mounting Poles and Mounting Accessories

Description	Minimum Specifications
Camera pole - 6Mtr	6 Metre Length Pole with Base Plate (250 x 250 x 6mm) 76.10mm OD x 3.65mm Thick x 6000mm Length Integral junction chamber flush with the pole for termination of CAT-6A and power cables. Including Bakelite sheet. Provided with a camera mounting plate - fixed to the pole with provision of holes for camera mounting - holes dimensions to be provided by you. PU coated through 5 tank cleaning process and with 2 coats of primer and 2 coats of PU paint and topcoat for extra weather protection. Poles are fine finished. The rate shall inclusive of all the necessary camera mounting accessories, back boxes, Termination Junction Boxes for power supply (if required), 4 Nos of Anchor bolt shall be 25mm dia and 500mm length, 2 Nos of 32mm GI pipe medium class collar bend for cable entry at the bottom of the foundation etc., to be considered. The Pole Cost shall be inclusive of all required RCC foundations as mentioned the foundation details of 450mm (L) x 450mm (W) x 1000mm (H) RCC M25 Grade. The Pole cost shall inclusive of excavation, shuttering, foundations and backfilling the soil etc. no extra cost shall be provided to Civil contractor.
Camera pole - 3Mtr	3 Metre Length Pole with Base Plate (250 x 250 x 6mm) 76.10mm OD x 3.65mm Thick x 3000mm Length Integral junction chamber flush with the pole for termination of CAT-6A and power cables. Including Bakelite sheet. Provided with a camera mounting plate - fixed to the pole with provision of holes for camera mounting - holes dimensions to be provided by you. PU coated through 5 tank cleaning process and with 2 coats of primer and 2 coats of PU paint and topcoat for extra weather protection. Poles are fine finished. The rate shall inclusive of all the necessary camera mounting accessories, back boxes, Termination Junction Boxes for power supply (if required), 4 Nos of Anchor bolt shall be 25mm dia and 500mm length, 2 Nos of 32mm GI pipe medium class collar bend for cable entry at the bottom of the foundation etc., to be considered. The Pole Cost shall be inclusive of all required RCC foundations as mentioned the foundation details of 450mm (L) x 450mm (W) x 1000mm (H) RCC M25 Grade. The Pole cost shall inclusive of excavation, shuttering, foundations and backfilling the soil etc. no extra cost shall be provided to Civil contractor.

Note: General Arrangement (GA) drawings and 4K Resolution images (previously executed at any of large-scale project) needs to be submitted by vendor before procuring the material at site. The material shall be rejected without any further reason by Consultant / Client if the material will be arrived at site without prior approval of above.

1.5.10 Weatherproof housing for Outdoor application

- The Housing should be made of extruded aluminium and should be weatherproof.
- The minimum internal dimensions of the housing should be capable of housing the camera.
- The camera housing should be:
 - ✓ Compatible to enclose the outdoor type cameras
 - ✓ Suitable for the make and model no of cameras offered and as specified by the manufacturer
 - ✓ Outdoor application enclosures shall be as per the approved camera OEM post order awarded.
 - ✓ Should be compact and indoor / outdoor type as required.
 - ✓ Suitable for operation in upright and inverted position'
 - ✓ Minimum IP 67 Class or higher weatherproof enclosure shall be proposed in case of outdoor mounting.

1.6 Integrated Building Management System - IBMS

1.6.1 System Architecture of IBMS

- The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate both the ANSI/ASHRAE Standard 135-1995 BACnet, and Modbus technology communication protocols in an interoperable system.
- The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135-1995, BACnet TCP to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet at all levels.
- All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a Master / Global / Host to pass data shall not be acceptable.
- Structured Query Language (SQL) or Java Database Connectivity (JDBC) or ORACLE compliant server database is required for all system database parameter storage. This data shall reside on a server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.
- Two (2) level hierarchical topology is required to assure fast system response times and to manage the flow and sharing of data.

1.6.2 Requirement of IoT Based BMS System

- Proposed Building Management System with IoT Platform server, which is located at the Integrated Building Management System (IBMS) server room on the second floor.
- It requires cloud-based server storage for the data collected by the IoT based BMS controller. Here are a few considerations for such a system:
 - **Integration Protocol:** Determine the protocol for integrating the IoT based BMS system with cloud server. Common protocols include MQTT, CoAP, or HTTP/HTTPS.
 - **Security:** Implement robust security measures to protect data during transmission and storage. This includes encryption, authentication, and access control mechanisms. Security shall comply with the requirement of cyber security UL-2900-1 compliances.
 - **Backup and Redundancy:** Implement backup and redundancy mechanisms to ensure data availability and integrity in case of system failures or disasters. Redundancy shall be complied with N : 1 configuration.
 - **Compliance:** Ensure compliance with relevant data protection and privacy regulations, especially when using cloud-based storage solutions.
 - **Monitoring and Analytics:** Implement monitoring and analytics tools to gain insights from the collected data, optimize building operations, and identify potential issues or inefficiencies. Controlling & Monitoring the BMS system as mentioned below-
 - ✓ Field equipments (Field level) shall be connected / interfaced to IoT Based BMS - DDC controller (automation level).
 - ✓ IoT Based BMS - DDC controller (automation level) shall be connected to BMS server (process level - I).
 - ✓ BMS 3D graphical software shall be installed / maintained at BMS server (process level).
 - ✓ IoT Based BMS - DDC controller shall be directly connected to Cloud Server (Process Level – II)
 - ✓ Incase Process Level – I will get failure at any point of time, The process Level – II will take over the operations.
 - **Maintenance and Support:** Establish procedures for ongoing maintenance, updates, and support for the IoT system to ensure its reliability and performance.
 - **Management:** IoT based BMS allows for a more seamless and efficient management of building systems. IoT technology enables the integration of various devices and systems of the building, creating a unified network that can be monitored and controlled remotely.
- Smart energy management with IoT involves using interconnected devices and sensors to monitor, control, and optimize energy usage in various applications.
 - **IoT BMS Controller:** IoT enabled BMS controller shall collect the data from the field level to measure energy consumption at various points in the system and the same shall be processed at process level I & II. It will used to track electricity, gas, water, and other forms of energy consumptions.
 - **Data Collection and Analysis:** Collect data from the sensors in real-time and analyse it to identify patterns, trends, and inefficiencies in energy consumption. Machine learning algorithms can be employed to predict energy

demand and optimize energy usage based on historical data and current conditions.

- **Demand Response:** Implement demand response strategies to adjust energy consumption in response to peak demand periods or pricing signals from utilities. This could involve automatically adjusting thermostat settings, dimming lights, or temporarily shutting down non-essential equipment.
- **Energy Efficiency Measures:** Implement energy efficiency measures based on insights gained from data analysis. This may include upgrading to more energy-efficient appliances and equipment, optimizing building layouts for natural lighting and ventilation, and improving insulation and weather sealing.
- **Integration with Renewable Energy Sources:** Integrate IoT systems with renewable energy sources such as solar panels and battery storage systems. This allows for better coordination between energy generation and consumption, maximizing the use of clean energy and reducing reliance on traditional grid sources.
- **Predictive Maintenance:** Utilize IoT sensors to monitor the health and performance of energy infrastructure and equipment in real-time. Predictive maintenance algorithms can detect potential faults or failures before they occur, allowing for proactive maintenance and minimizing downtime.
- **User Engagement and Feedback:** Provide users with feedback on their energy consumption habits through smart meters, mobile apps, or web interfaces. This encourages energy-saving behaviours and empowers users to make informed decisions about their energy usage.

1.6.3 Web Browser Clients

- The system shall be capable of supporting an unlimited number of users using a standard Web browser. Systems requiring additional software (to enable a standard Web browser) to be resident on the DDC / client machine, or manufacture-specific browsers shall not be acceptable. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser.
- The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
- The Web browser client shall support at a minimum, the following functions:
 - User log-on identification and password shall be required. If unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
 - Graphical screens developed for the GUI shall be the same screens used for the Web browser client.
 - HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
 - Storage of the graphical screens (Static) shall be stored in DDC directly and should not depend on any other hardware.

- The Web page shall get automatically refreshed without any user intervention.
- Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
 - Modify common application objects, such as schedules, calendars, and set points in a graphical manner. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator and set holidays
 - View logs and charts
 - View and acknowledge alarms
- The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to adjust their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
- Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

1.6.4 System Description & Input Output Summary

- The proposed system shall be a Direct Distributed Digital Control (DDC) system. It shall be a PC based system and shall combine latest state of the art technology with simple operating techniques. The entire Monitoring of Building Management System (BMS) shall be comprised of a network of interoperable, stand-alone digital controllers communicating on an open protocol communication network to a host computer within the facility and communicating via the Internet to a host computer in a remote location. The BMS shall communicate to third party systems such as Chillers, Energy meters, UPS, DG, Lifts, VFDs & breakers, fire-life safety systems and other building management related devices with open, interoperable communication capabilities.
- The BMS framework shall utilize built-in Internet connectivity to a broad range of distribution partners in the building automation, energy services, power/utility, and industrial sectors. The Framework shall bring together the ongoing computerization of control applications under single integrated system architecture.
- The features shall be distributed both physically and functionally over the field controllers. Microprocessor based Direct Digital Distributed Controllers (DDC) shall interface with sensors, actuators and environmental control systems and carry out followings functions:
 - Individual input/output point scanning, processing, and control.
 - Centralized operation of the plant (remote control).
 - Static / Dynamic graphic details of plant and building.
 - Energy Management through optimization of all connected electrical and mechanical plants.
 - Alarm Detection and early recognition of faults.
 - Time, event and holiday scheduling as well as temporary scheduling.
 - Prevention of unauthorized or unwanted access.
 - Communication interface and control.
 - Suggestive preventive maintenance for all equipment as well as own error diagnosis.
 - Report generation.

- Optimum support of personnel.
- Data Visualization Tool
- These Controllers shall be capable of functioning on a stand-alone mode i.e. in case of loss of communication with the central control station / Server, these shall function independently. DDC shall have microprocessors built-in as standard, which control the respective operation centers based on the required logic and also offer fast communication of data via the network communication system. The local access to these shall be either through an in-built display with keypad for each outstation or through a portable operator's terminal. The controllers shall be capable of executing advanced control algorithms like Optimum Start stop, PID control, auto PID tuning and schedule management. They shall also execute logic functions based on time and/or event. Totalization and averaging functions shall be an inherent feature of the controller.
- Each stand-alone intelligent DDC Controller shall have a Dual 32-bit processor, on board Ethernet connectivity. These shall also control any other operations on the floor and shall be sized to suit the operation centers or system requirement. This shall help in reducing the site electrical installation.
- The number of controllers for central plant room equipments shall be decided by the contractor. Overall, the system shall be provided with 20% spare capacity, with spare of at least 20% points in each type of IO point in each controller.
- There shall be one BMS control station located in Control Room. The Operator Station should use a simple Web Browser in conjunction with the BMS Server software. The computer shall be sized to cover the graphic display memory, planning information, software & data storage requirement. The display shall be in the form of dynamic colour graphics and text format with menu driven pop-up windows and help facility.
- The following software packages shall be loaded into the system as minimum standard: -
 - Complete system operational software
 - Site specific data manipulation software
 - 3D Graphical software
 - Alarm indication software
 - Internet Enabled Remote Monitoring Package.

1.6.5 Central Stations Software and Hardware

- A central server, located at IBMS Server Room, shall be provided. The server shall support all DDC's connected to the customer's dedicated common network and remotely connected to the cloud server.
- Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, PSTN or dial-up connection.
- It shall be possible to provide access to all DDC & 3rd party integration units via a single connection to the server. In this configuration, each DDC can be accessed from the Graphical User Interface (GUI) or from a standard Web browser (WBI) by connecting to the Local Area network.
- The server software shall provide the following functions, at a minimum
 - Complete control and monitoring of IBMS system from colour graphics pages on the machine, or from a remote web browser.
 - Full client-server operation.

- SQL / JDBC / ORACLE Database.
- Comprehensive alarm handling with alarm retransmission and logging.
- Scheduled recording of logged data from DDC.
- Management of multiple controller occupation times.
- Multilevel security system.
- International language support
- Display of HTML pages from company Intranet, or Internet.
- Display of live, logged, or recorded data in multi-trace graphs.
- Simple engineering path using drag and drop operations.
- Self-learning of all local networks.
- Help file in PDF format for viewing or printing.
- Access to the configuration mode of devices.
- Display all devices on the system connected via LANs, internet works, autodialled links, and Ethernet Network connections.
- Customised program creation environment.
- The BMS software shall be simple, flexible, and convenient to use such that an operator with minimal programming knowledge can use it to perform control / monitoring and to build programs for control applications, graphics to generate management information systems (MIS) reports. As well, on higher end it shall be possible to create customized programs to suite the site requirement by a software programmer. All necessary documents required to make customization possible should be available along with the software without any additional charge.
- The operating system shall be the Microsoft Windows 11 / 64-bit multitasking environment. The networking software shall use the TCP / IP LAN protocol. The system shall be capable of supporting up to 25 simultaneous operator workstation connections but however presently we need Five User Option.

1.6.6 Monitoring and Control Functions

- **Monitoring:**
 - The system shall support data acquisition using periodic scanning, exception reporting or on operator request. The system shall support a range of scan intervals, ranging from less than 5 second up to several minutes as desired / required. The system shall allow certain selected points to be scanned more often / faster than other points.
 - The communication techniques shall be optimized to minimize network traffic while providing good system response and reliability. The system shall also provide utilities to compile aggregate statistics on communication link usage.
- **Controlling:**
 - Control transactions issued by the operator shall be communicated to control devices using a write followed by read to ensure the integrity of the transaction. If the read following the write to the device indicates that the control action has failed, the operator shall be informed by means of a control failure alarm. The priority of the control failure alarm shall be configurable by the user.

1.6.7 System Database

- The system shall provide a real-time database incorporating data from analogue, logical or pulse inputs. The database shall be configurable by the end user without the need for any programming and shall be able to modify on-line without

interrupting operation of the system. In addition to point-based information, the database shall also provide historization capabilities for analogue, digital, pulse; event-based information and calculated values. This information shall be accessible by all facilities of the system such as custom displays, reports, trends, user written application, etc.,

- The real-time database shall use suitable data structures to collect and store the following categories of data, as minimum.
 - Access points
 - Analogue points
 - Status points
 - Accumulator points
 - Historical data
 - Event data
- The facility shall also exist to accommodate user defined data structures.
- Each of the point database structures shall be comprised as a composite point with a number of associated parameters that may be referenced relative to a single tag name. Specifically, each of these parameters shall be accessible by various sub-systems such as the graphical operator interface, report generation system and application program interface in a simple format without the need to know any internal storage mechanism.
- The system shall maintain portions of the data base requiring frequent high-speed access as memory resident information and other less frequently accessed data as disk resident data.
- Database backup shall be possible with the system on-line including backup of historical based data. The database backup shall be part of GUI software & shall be possible to configure automatic backup at regular interval without any user interference / attention. All other backup such as graphic pages / drawing etc can be windows based where simple copy & paste should be enough for taking backup other than database. Long term storage of this data shall be possible using the zip drive. The system shall have the provisions for importing this data at later date for analysis and long terms MIS reports.
- Point data shall be stored in a composite point database structure that provides a wide range of configurable information including but not limited to:
 - Point name and description
 - Multiple locations for data storage and device scanning addresses.
 - Scan period
 - Multiple dead-band or hysteresis settings
 - Monitoring and control access restriction information.
 - Location of operator alarm handling instructions
 - Location of ancillary information associated with the point.

1.6.8 Historical Data Storage

- Collection of historical point data shall be configurable as part of the point definition. Once configured, this data shall be collected automatically. Historical data collection shall be provided for both snapshots and averages with intervals ranging from 5 seconds to several hours.

- The system shall provide the necessary means to easily locate the particular value of interest for any of the historical points. The graphical operator interface, trend, report generation and application interfaces shall be able to access historical data.

Trending

- The system shall provide flexible trending allowing real-time, historical, or achieved data to be trended in a variety of formats. In addition, trend data types shall be able to combine to allow for comparisons between data e.g., current real-time data versus archived data. The system shall provide trending capability with following functions.
 - Real time trending
 - Historical trending
 - Archived history trending
 - Trend scrolling
 - Trend zooms
 - Export option / Copying of currently displayed trend data to the clipboard for pasting into spreadsheet or document.
- The system shall allow the trending of a minimum of 5 points in a single trend display set. For each trend set display it shall be possible for operators to configure the number of historical samples and ranges displayed. Points configured in trend sets shall be changeable on-line.
- Operators shall be able to zoom in on information displayed on trend sets for closer inspection by dragging out an area of interest with the mouse or other pointing devices. From such a selection, it shall be possible to copy the underlying data to the windows clipboard for subsequent pasting into spreadsheet application such as Microsoft excel

1.6.9 Alarm Management

- The software shall include a well-organized alarm management facility to enable the operator to react quickly and efficiently to alarm conditions. Apart from the specific points identified for alarm annunciation in the I/O points schedule, the alarm types supported shall include:
 - Very high value alarm
 - Very low value alarm
 - Large deviation alarm
 - Rate of change alarm
 - Unreasonable value alarm
 - Delay to avoid nuisance alarm / short time change in value
- The system shall permit any of these alarm types to be applied to the analog and accumulated points.
 - The software shall permit at least 90 levels of alarm priorities to be assigned to each alarm ranging from the lowest to the highest. These levels shall be easily distinguished by the way they are presented such as the colour of the alarm message, blinking of the alarm message, varying audible alarms, etc., All alarm shall be logged in the event / alarm file and / or on the alarm printer. On acknowledgement of an alarm, it shall be possible to automatically issue a reset command to the controller so as to attempt to reset the alarm point.

1.6.10 Reporting

- The system shall support a flexible reporting package to allow easy generation of report data. The reports provided shall include pre-configured standard reports for common requirements such as alarm / event reports and custom report generation facilities that are configurable by the user.
- The following pre-formatted reports shall be available on the system:
 - Alarm / event report
 - Operator trail report
 - Point trail report
 - Alarm duration report
 - All point reports
 - Point attribute report
 - Lockout summary
 - Over-ride summary
- Configuration of these reports shall only require entry of the schedule information, and other parameters such as point name or wildcard, filter information, time interval for search and destination printer to fully configure the report. No programming shall be required.
- The requirement of the above-mentioned reports shall be as follows:
 - **Alarm/Event Report**
 - ❖ This report shall be summary of all events of a specified type for nominated points occurring in a time period. The time period may be specified as an absolute start and end date and time, or as a period to the current time.
 - **Operator trail report**
 - ❖ This report shall be a summary of all operator actions relating to a specific operator in a specified period.
 - **Point trail report**
 - ❖ This report shall be provided to produce a summary of all events of a specified type occurring in a period on nominated points.
 - **Alarm duration report**
 - ❖ This report shall be provided to calculate the total amount of time a nominated point or group of points has been in an alarm condition over a given time period.
 - **All point reports**
 - ❖ A report shall be provided to produce a list of point information, including point name, description, point type, engineering units, and current values.
 - **Point attributes report**
 - ❖ A report shall be provided for summaries of the points selected as per the following criteria:
 - Out of service
 - Alarm suppressed
 - Abnormal input levels
 - In manual mode.
 - **Over-ride summary**
 - ❖ This report shall be used to provide the summary of all points / commands that have been over-ridden by the operator.

Time Schedules

- The system shall include the facility for time scheduling activities on both a periodic and one-off basis. All time schedules shall be configurable via the Operator workstation. Each time schedule entry shall consist of:
 - Date
 - Time
 - Point name
 - Point Parameter
 - Target Value
 - Type of scheduling
 - The available time schedule type shall include:
 - ❖ Daily – to be executed everyday
 - ❖ Workday – to be executed on the weekdays
 - ❖ Holidays – to be executed on holidays
 - ❖ Individual days – to be executed on a particular day
 - The system shall also have the provision for programming temporary schedules that over-ride the normal schedule.

1.6.11 Energy Monitoring & Analysis

- Energy Monitoring & Analysis should be integral part of GUI. It shall support minimum of 50 Energy points for analysis purpose. The software shall provide the following feature but are not limited to,
 - It shall be possible to generate & view detailed Daily, Weekly & monthly graphs of the energy meter / point identified.
 - It shall be possible to see and analyse the total energy usage in a building and also shall be possible to identify by which system is major user of the energy.
 - It shall be possible to compare the energy points week against week, day against day in a month, identify Maximum, Minimum & average daily values & Energy usage for different periods of time of the day.
 - It shall be possible to make cost and consumption analysis or CO2 reports on consumption.
 - Based on the energy consumed it shall be possible to rank the systems or building (in case of multi-location buildings)
 - Software shall allow the user to compare the predicted / forecasted energy or based on historic performance with current performance.
 - It shall be possible to create energy signature with respect to ambient / outside temperature of the day
 - Software shall allow the user to identify the exceptions happened in the system due to which energy consumption was increased.
 - It shall be possible to compare the energy consumption after introducing a energy saving strategy for further fine tuning or to visualize the savings achieved.

1.6.12 Operator Interface

- The operator interface provided by the system shall through an intuitive graphical user interface and shall allow for efficient communication of operational data and abnormal conditions. It shall provide a consistent framework for viewing of information. Critical areas (such as alarm icons) shall be visible all the time. A

predefined area on the screen shall provide operator messaging, and this area shall also be visible at all times.

- The operator interface shall be interactive and based on graphics and / or icons. Standard tool bar icons and drop-down menus shall be available on all standard and custom display to allow easy access to common functions.
- The system shall provide an operator interface with the following minimum capabilities:
 - Window re-size, zoom in, zoom out.
 - Dedicated icons and pull-down menus to perform the following:
 - Associated display
 - Alarm summary
 - Alarm acknowledgement
 - Previous display recall
 - Graphic call-up
 - Trend call-up
 - Point detail
 - Current security level
 - Alarm annunciation
 - Communication fail annunciation
 - Operator message zone.

1.6.13 Area Assignment / Area Profile

- Each operator shall be assigned one or more specific areas / functions of the facility with the appropriate monitoring and control responsibility. An area shall be defined in this context as a logical entity comprising of a set of points in the system. This in turn may represent a physical space in the facility or a particular utility or a particular equipment.
- The system shall provide the facility to create area profiles, which combine areas and time periods, and which can be assigned to operators with the same area access requirements. By using area profiles in this way, area access can be specified to apply during certain time periods, allowing different areas of access at different times of the day or week.

1.6.14 Command Partitioning

- It shall be possible to assign to each operator a set of allowed commands / operating for each assigned area. With this feature, it shall for example be possible to configure an operator to set a digital point to On, but to disallow the same operator from setting the same digital point to OFF.

1.6.15 Standard System Displays

- The following displays shall be included as part of the system:
 - Alarm summary display
 - Event summary display
 - Point detail template displays
 - Trend set template displays
 - Communication status displays
 - System status displays
 - Operator scratch-pad display.

1.6.16 System Status Displays

- These shall display the following information
 - Points in alarm condition pending acknowledgement
 - Points which remain in an alarm condition state, but which have been acknowledged.
 - Communication failure
 - Printer Status
 - Operator workstation status
 - Controller status

1.6.17 Administrative Displays

- The system shall provide the following full screen display
 - Master system menu
 - Report summary
 - Alarm summary
 - Event summary
 - Display summary.
 - Area assignment
 - Holiday assignment
 - History assignment
 - Push-button assignment
 - Operator definition
 - Operator message board
 - Events archive and retrieval
 - Time period summary

1.6.18 Other Requirements

- It shall be possible to launch any windows-based applications, such as Microsoft word or Microsoft excel, from within the operator interface.

1.6.19 Help Facility

- Software shall be provided to facilitate programming and storage of the system operation manuals in the hard disk. The operation manual shall be retrieved by Online Help mode so as to enable the operator to self-learn the system operation, command, or function as and when needed.
- This 'help' facility shall be made available to the operator by use of a dedicated key, or a single key click on the mouse. A minimum help shall be available for every menu item and dialogue box.
- The facility shall contain both text and graphics to provide information about the selected function directly.
- The information provided shall be in simple clear language and shall be possible to search the help based on typical word included in the process.
- When a point is overridden by operator command from an operator workstation or a local workstation, an alarm message shall be output to the appropriate alarm printer and to respective operator workstation. Alarm messages shall require operator acknowledgement.
- When a point returns to normal, the event shall be recorded in control stations as 'Return to Normal'.

- The Operator workstations shall be capable of displaying a list of all points in alarm for the building in a single summary. Systems which require the operator to make a separate summary for alarms shall not be acceptable. The software shall also provide details of particular alarm occurred on a point.

1.6.20 Compliance

- The computer system software and hardware should be 21 CFR part 11 compliant.
- Therefore, vendor to carry out system qualifications accordingly
- All instruments, software supplied shall be validated, tested, and certified complying to 21 CFR Part – 11.
- Contractor shall strictly follow the procedures as laid down in the necessary guidelines.

1.6.21 Third Party System Integration Units

- The 3rd party Integration unit shall provide the interface between Ethernet LAN and the 3rd party field control devices such as DDC or PLC or any other devices which need to be integrated. These shall also provide supervisory capability of functions over the devices connected to it. The purpose of using these units should be limited to integrate devices only, not for any DDC interface with GUI, provided by others.
- The Unit must provide the following hardware features as a minimum:
 - One no. on board RS-232 port
 - One No. on Board RS-485 port
 - Provision to include / add additional communication card
 - Battery Backup
 - Minimum RAM of 128 MB & Flash of 64MB
- The Unit must communicate over TCP/IP with communication speed of 10/100MBPS.
- The Integration unit shall have built in drivers for open protocol such as
 - BACnet over MSTP
 - BACnet over IP
 - Modbus over MSTP
 - Modbus over IP
 - Lon FTT
 - Lon IP
 - Mbus over TCP
 - Mbus Serial
 - SNMP
- If the above drivers are add-on products, it shall be made available / considered while selecting the unit & the same to be confirmed in writing.
- The Integration unit shall provide flexibility of adding communication ports (RS485) by adding communication cards, minimum one slot, when required rather than adding additional unit itself.
- The Integration unit shall have inbuilt JAVA engine and it shall be possible to configure the IO, if required, of the 3rd party devices.
- The Integration unit should be capable of handling multiple protocol simultaneously and should not be restricted to single protocol.

- The Integration unit should have inbuilt memory for program storage.
- The Integration unit should automatically backup its database for the user defined interval.
- User authentication should be integral part of the unit.
- All vendors are required to provide the documentation highlighting the capabilities mentioned above.
- All units shall have LEDs for fault / status identification such as
 - LAN active (one per port in case of multiport units)
 - LED to display proper functionality / Status of the unit.
 - LED to display healthiness of CPU of the unit.

1.6.22 Direct Digital Controller (DDC)

- **DDC Hardware Requirement**
 - DDC controllers shall be capable of fully “stand- alone” operation i.e. In the event of loss of communication with other DDC’s or Control Station, they shall be able to function on their own.
 - The controllers shall be built in Dual 32-bit microprocessors for reliable throughput, with EEPROM based operating system on BACNET
 - The memory available to the controller board should serve as working space and there should not be any limitation of using particular function block other than the memory.
 - The controllers shall be UL listed and conforming to CE.
 - The controller shall have support programs built in RAM for minimum of 120 hours in the event of a power failure and it shall be possible to fit any battery thus expanding the time limit to 5 years. An alarm shall be generated on low battery voltage. The battery shall not be required to supply power to actuators, valves, dampers etc.
 - DDC shall have embedded TCP/IP connectivity so that it can be hooked into the Local Area Network (LAN) provided by the client / can be on dedicated network created by the vendor. Each DDC can be accessed from the Graphical User Interface (GUI) or from a standard Web browser Interface (WBI) by connecting to the server.
 - Controller shall have capability to communicate with other controllers for any interlock or data sharing using peer to peer technology. The Controller which routes the messages or data sharing through the system, or any intermediate hardware / controller shall not be acceptable.
 - Vendor to demonstrate this capability during the commissioning time and the same shall be verified at the time of handing over.
 - Each controller shall have an inbuilt 1 Nos of RS-232 Port and Dual RS-485 Ports. So that any trouble shooting required at field level can be carried out without removing the controller from the network (LAN).
 - Power provision via 230V, 50Hz Uninterrupted power supply shall be provided by end user, the conversion to 24V AC power to cater to the controller shall be considered as part of the DDC panels supplied by BMS vendor. Hardware such as transformers and SMPS etc to be considered accordingly by BMS vendor.
 - Controller shall support DHCP addressing over Local Area Network (LAN) so that the static IP requirements are reduced however a single static IP shall be

provided for system so that it can be hosted on to internet in consultation with end user / consultant.

- All controllers shall have capability to provide 24V DC auxiliary power supply for the sensor which requires power, however the same shall not be required to high power consuming devices / equipments such as actuators, dampers etc.
- Vendors to provide details on the same at the time of offer.
- The Controllers shall have proportional control, Proportional + Integral (PI) Control, Proportional plus Integral plus Derivative (PID) Control, Two Position Control and Time Proportioning Control and algorithms etc, all in its memory and all available for use by the user, i.e., all the control modes shall be software selectable at any time and in any combination. The analog output of Proportional Control, PI Control, and PID Control shall continuously be updated and output by the program shall be provided. Between cycles the analog output shall retain its last value. Enhanced integral action in lieu of Derivative function shall not be acceptable.
- Automatic loop tuning facility should be available to tune the loop at regular interval and adjust the gain or the integral / derivative time.
- The controllers shall have a resident real time clock for providing time of day, day of week, date, month, and year. These shall be capable of being synchronized with system / time master clocks in the network.
- Upon power restoration all clocks shall be automatically synchronized to the time master controller which will be set during the commissioning phase.
- The microprocessor based DDC's shall be provided with power supply, A/D and D/A converters, memory, and capacity to accommodate a maximum of 160 input/output (I/O) hardware points (with or without an expansion board).
- If the controllers provided by the contractor have the configurable plug-in function cards, then the following minimum specifications shall have to be met:
- The cards shall provide for analog or digital, input or output, hardwired connections to the installed plant.
- The quantity and combination of these cards shall be determined by the requirements of the plant in that location with the concurrence of the Owner/ Consultant.
- The DDC's shall have 20% spare capacity for each type of point (digital/analog input/output) of each DDC Panel to give flexibility for future expansion.
- All DDC controllers shall have 10 / 12-bit A/D resolution and be capable of handling voltage, milli-ampere, resistance, or open and closed contacts inputs in any mix, if required.
- Analog inputs/outputs of the following minimum types shall be supported:
 - ✓ 4-20 mA.
 - ✓ 0-10 volts.
 - ✓ 2-10 volts.
 - ✓ Resistance Signals (either PTC or NTC such as PT 1000, PT 3000, NTC20K)
- Digital input/output types to be supported shall be, but not limited to the following:
 - ✓ Normally open contacts.
 - ✓ Normally closed contacts.

✓ Pulse inputs

Note: Modulating outputs shall be true proportional outputs and not floating control type.

- It shall be possible to change the analog inputs to accept any of the above depending upon the site condition or system requirement using a jumper. The DDC which is configured using software trigger / switch shall not be acceptable.
- Controller's packaging shall be such that, complete installation and check out of field wiring can be done prior to the installation of electronic boards.
- All board terminations shall be made via plug-in connectors to facilitate troubleshooting, repair, and replacement. Soldering of connections shall not be permitted.
- Controllers shall preferably be equipped with diagnostic LED indicators with at least indication for Power up Test OK, Watch dog and Bus Error. All LEDs shall be visible without opening the DDC cover.
- It shall be possible for the controllers to accept regulated uninterrupted power supply to maintain full operation of the controller functions (control, logging, monitoring, and communications) in the event of a localized mains failure.
- Controllers requiring fan cooling are not acceptable.
- There shall be the facility for accessing controller data information locally, via a portable plug-in colour LCD display which will be common to all controllers and normally removed to prevent unauthorized tampering. In either case, access to the system thus provided shall be restricted by passwords in the same way as at the main operator terminal.
- In case the Portable operator Terminals (POT) are required to program the controllers, sockets shall be provided for same. Attachment of POT shall not interrupt or disable normal panel operation or bus connection in any way.
- The controllers shall be housed in vandal proof boxes to protect them from tampering by any unauthorized personnel. All DDC controllers used in plant room spaces and external application shall be housed IP66 rating enclosures. All DDC located inside the building shall be with a minimum of IP 55 rating enclosures.
- It shall be possible to add new controllers to the system without taking any part of the system off-line.
- All DDC should have XML web service option which can be enabled in later stage for any higher interface with IT infrastructure or any other service.
- Individual DDC should be BTL (BACnet Testing Lab) tested.
- **DDC Capabilities:**
 - The Controllers shall have a self-analysis feature and shall transmit any malfunction messages to the Control Station. For any failed chip the diagnostic tests, printout shall include identification of each and every chip on the board with the chip number/location and whether the chip "Passed" or "Failed" the diagnostic test. This is a desired requirement as it would facilitate troubleshooting and ensure the shortest possible down time of any failed controller. Controllers without such safety feature shall be provided with custom software diagnostic resident in the EEPROM. The tenderer shall confirm in writing that all controllers are provided with this diagnostic requirement.
 - Operating system (O.S.) software for controllers shall be EPROM resident.

- Controllers shall have resident in its memory and available to the programs, a relevant library of algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences.
- In the event of failure of communication between the controllers and/or Control Station terminal, alarms, reports, and logs shall be stored at the controllers and transmitted to the terminal on restoration of communication.
- In the event of memory loss of a Controller or the expiration of back-up power, on start-up of the unit the necessary database shall be downloaded manually so that the logic built are verified by the user. However, controllers requiring a manual intervention for the re-boot of software are not desired.
- Where information is required to be transmitted between controllers for the sharing of data such as outside air temperature, it shall be possible for global points to be allocated such that information may be transmitted either on change of incremental value or at specific time intervals.
- Controllers must be able to perform the following energy management functions as a minimum,
 - ✓ Time & Event programs
 - ✓ Holiday Scheduling
 - ✓ Maximum and Distributed power demand
 - ✓ Optimum start and stop program
 - ✓ Night purge
 - ✓ Load reset
 - ✓ Zero energy band
 - ✓ Duty cycle
 - ✓ Enthalpy analysis and control
 - ✓ Run Time Totalization
 - ✓ Sequencing and Optimization
 - ✓ Exception scheduling

Note: Detailed description of software features and operating sequence of all available energy management software shall be submitted with the tender for evaluation by the consultant.

- The DDC Controllers shall have Adaptive Control capability whereby the control software measures response time and adjusts control parameters accordingly to provide optimum control. The software shall allow self-tuning of the variable control loops (all or any of P, P+I, P+I+D) of the AHUs to provide the most efficient and optimized controls at different load conditions. The energy management programs shall update their parameters based on previous experience & current operating conditions.
- Alarm Lockout shall be provided to prevent nuisance alarms. On the initial start-up of air handler and other mechanical equipment a “timed lockout” period shall be assigned to analog points to allow them to reach a stable condition before activating an alarm comparison logic.
- Tenderers shall indicate their proposed system alarm handling capability & features.
- Run time shall be accumulated based on the status of a digital input point. It shall be possible to total either ON time or OFF time. Run time counts shall be resident in non-volatile memory.
- It shall be possible to accommodate Holiday and other planned exceptions to

the normal time programs. Exception schedules shall be operator programmable up to one year in advance.

- All DDC shall have trend / log storing capacity in built into it. It shall be possible to have stored the data for at least 40 days @ 1 hour sampling time for all the points of the DDC (used or unused).
- Minimum communication should be 10MBPS for each of the controller.
- DDC should be forward compatible type so that any expansion or upgrade of the system required in the future is easily taken care off without scrapping / removing / disturbing the existing working system.
- DDC Should allow user to include graphics, if required, however it shall be of static in nature.
- All DDC Should be capable of sending email to specific user in the event of alarm, identified by end user / consultants.

1.6.23 Portable Operators Terminal (POT)

- POT shall be provided to allow operator readout of system variables, override control and adjustment of control parameters. The POT shall be portable and plug directly into individual controllers for power and data.
- The minimum functionality of POT shall include:
 - Set points to a fixed value or state.
 - Display diagnostic results.
 - Display sequentially all point summary and sequentially alarm summary.
 - Display/change digital point state, analog point value.
 - Display/change time and date.
 - Display/change analog limits.
 - Display/change time schedule.
 - Display/change run time counts and run time limits.
 - Display/change time and/or event initiation.
 - Display/change programmable offset values.
 - Access DDC initialization routines and diagnostics.
 - Enable/disable points, initiators and programs.
 - Display/change minimum ON/OFF and maximum OFF times.
- The POT shall be complete with command keys, data entry keys, cursor control keys or liquid crystal display (LCD). Access shall be via self-prompting menu selection with arrow key control of next menu/previous menu and step forward/backward within a given menu.
- Connection of a POT to a controller shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or interfere with Control Station commands and system modifications.
- Connection of POT at any controller shall provide display access to all controllers on that bus. In case the controller has a fixed LCD display and entry keyboard, then the display access shall be available on each screen.
- It should be possible to override the commands given through POT by the Operator Control Station.
- POT shall have touch screen colour display and it shall be possible to hook this to Local area Network so that the entire system data can be visualized.
- POT shall have self-learning capability so that it can recognize the DDCs on the network and update all points without any manual programming.

1.6.24 Data Communications

- The communication between controllers shall be via a dedicated or customer provided Ethernet communication network as per standards. Controller's microprocessor failures shall not cause loss of communication of the remainder of any network. All networks shall support global application programs, without the presence of a host PC.
- Each controller shall have equal rights for data transfer. There shall be no separate device designated as the communication's master. Those systems using dependent controllers shall be pointed out by the contractor and a dual Hot redundant transmission media with automatic switching and reporting in the event of line faults will have to be provided.
- The communication network shall be such that:
 - Every DDC must be capable of communicating with all DDC's on its own.
 - Network connected devices shall be capable of sending message after successive retries shall constitute a communication or device failure.
 - Each controller is to be provided with a communication watchdog to assure that the failure is reported to central station.
 - Error recovery and communication initialization routines are to be resident in each network connected device.
 - The communication protocol shall incorporate CRC (Cyclic Redundancy Check) to detect transmission errors.
- Single or multiple standalone controller failures shall not cause loss of communication between active DDCs connected on the communication network. Full communication shall be sustained as long as there are at least two operational standalone control panels active on the communication network.
- All the System Integration Units shall be linked together on a Local Area Network.
- The communication network shall include provision for automatically reconfiguring itself to allow all operational equipment to perform as efficiently as possible in the event of single or multiple failures.
- The BMS supplier shall be required to provide details of standards to which their system conforms.

1.6.25 Field Devices

- **Electric and Electronic Controls Related Equipment**
 - **General Requirements**
 - ✓ All controls shall be capable of operating in ambient conditions varying between 0-55 deg. C and 90% R.H. non-condensing.
 - ✓ All Control devices shall have a 20 mm conduit knockout. Alternatively, they shall be supplied with adaptors for 20 mm conduit.
 - **Ancillary Items**
 - ✓ When items of equipment are installed in the situations listed below, the BAS contractor shall include the following ancillary items:
 - **Weather Protection**
 - ✓ All devices required to be weatherproofed are detailed in the Schedule of Quantities. IP ratings for the equipment are mentioned in the respective section.
 - **Pipework Immersion**

- ✓ Corrosion resisting pockets of a length suitable for the complete active length of the device, screwed ½" (13 mm) or ¾" (20 mm) NPT suitable for the temperature, pressure and medium.
- **Duct Mounting (Metal or Builders Work)**
 - ✓ Mounting flanges, clamping bushes, couplings, locknuts, gaskets, brackets, sealing glands and any special fittings necessitated by the device.
- **Temperature Sensor**
 - Temperature sensors for space, pipes, and ducts, shall be of the Resistance Temperature detector (RTD) type or thermistor. These shall be two wire type and shall conform to the following specifications:
 - ✓ Immersion sensors shall be high accuracy type with a high resistance versus temperature change. The accuracy shall be at least ± 2 deg C.
 - ✓ Immersion sensors shall be provided with separate Brass thermo-well. These shall be manufactured from bar stock with hydrostatic pressure rating of at least 10 kgf/cm².
 - ✓ The connection to the pipe shall be screwed type. An aluminum sleeve shall be provided to ensure proper heat transfer from the well to the sensor. Terminations to be provided on the head. Flying leads shall not be acceptable.
 - ✓ The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections.
 - ✓ Duct temperature sensors shall be with rigid stem and of averaging type. These shall be suitable for duct installation.
 - ✓ Outdoor air temperature sensor shall be provided with a sun shield.
 - ✓ The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.
 - ✓ The temperature sensors may be of any of the following types:
 - ❖ PT 1000, PT 3000
 - ❖ Thermistor
- **Humidity Sensor**
 - Space and duct humidity sensors shall be of capacitance type with an effective sensing range of 0% to 93% RH. Accuracy shall be + 2% or better.
 - Duct mounted humidity sensors shall be provided with a sampling chamber.
 - Wall mounted sensors shall be provided with a housing.
 - The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections.
 - The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.
- **Pressure Transmitter – Water Type**
 - Pressure transmitters shall be piezo-electric type or diaphragm type. (Bourdon Tube type shall not be acceptable).
 - Output shall be 4-20mA or 0-10V DC and the range as specified in the data sheet depending on the line pressure.
 - Power supply shall be either 24 V AC, 24 VDC or 230 V AC.
 - Connection shall be as per manufacturer's standards. The pressure detector shall be capable of withstanding a hydraulic test pressure of twice the working pressure.

- The set point shall fall within 40%-70% of the sensing range and detector shall have sensitivity such that change of 1.5% from the stabilized condition shall cause modulation of the corrective element.
- The sensor must be pressure compensated for a medium temperature of -10° C to 60° C with ambient ranging between 0° C to 55° C.
- **Differential Pressure Switch – Water Type**
 - These shall be used to measure pressure differential across suction and discharge of pumps.
 - The range shall be as specified in the data sheet. Switch shall be ON with increase in differential.
 - Housing for these shall be weatherproof with IP 55 protection.
 - The pressure switch shall be capable of withstanding a hydraulic test pressure of 1.5 times the working pressure.
 - The set point shall fall in 40-70% of the scale range and shall have differentials adjustable over 10%-30% of the scale range.
 - The switches shall be provided with site adjustable scale and with 1 NO/NC contacts.
- **Differential Pressure Switch – Air Type**
 - These shall be diaphragm operated. Switches shall be supplied with air connections permitting their use as static or differential pressure switches.
 - The switch shall be of differential pressure type complete with connecting tube and metal bends for connections to the duct.
 - The housing shall be IP 54 rated. The pressure switches shall be available in minimum of 3 ranges suitable for applications like Air flow proving, dirty filter, etc. The set point shall be concealed type.
 - The contact shall be SPDT type with 230 VAC, 1A rating.
 - The switch shall be supplied suitable for wall mounting on ducts. It should be mounted in such a way that the condensation flow out of the sensing tips. Proper adaptor shall be provided for the cables.
 - The set point shall fall within 40%-70% of the scale range and I has differentials adjustable over 10%-30% of the scale range.
 - The switches shall be provided with site adjustable scale and with 1 NO/NC contacts.
- **Air-Flow Switches**
 - Air flow switches shall be selected for the correct air velocity, duct size and mounting attitude. If any special atmospheric conditions are detailed in the Schedule of Quantity the parts of the switches shall be suitably coated or made to withstand such conditions.
 - These shall be suitable for mounting in any plane. Output shall be 1 NO/NC potential free. Site adjustable scale shall also be provided.
- **Air-Pressure Sensor**
 - The pressure sensor shall be differential type. The construction shall be spring loaded diaphragm type.
 - The movement of the membrane in relation to the pressure should be converted by an inductive electromagnet coupling which would give an output suitable for the controller.
 - The pressure sensor shall be in a housing having IP 54 ratings in accordance with IEC 529. Suitable mounting arrangement shall be available on the sensor.

The sensor shall come complete with the PVC tubes & probes.

- **Water Flow Switch**
 - These shall be paddle type and suitable for the type of liquid flowing in the line. Output shall be 1NO/1NC potential free.
- **Carbon-Monoxide Sensor**
 - CO Sensor shall be integrated Surface mounted type on the field.
 - These shall work on 24V AC/DC supply with the output being standard type i.e. 4-20 mA / 0- 10 Volts etc.
 - Response time of the detector shall be <10 minutes. Range of the sensor shall be 0 to 2000 PPM
- **Air Velocity Sensor**
 - Air Velocity Sensor shall be integrated Surface / Duct mounted type on the field. These shall work on 24V AC/DC supply with +/- 10% variation the output being standard type i.e., 4-20 mA / 0- 10 Volts etc with an accuracy of +/- 3%.
 - It shall be possible to select the different ranges by changing the jumpers on the sensor. At least 3 selection ranges on the sensors are required.
- **Co2 Sensor – Space Type**
 - Co2 Sensor shall be wall / Surface mounted type on the field. These shall work on 24V AC/DC supply with the output being standard type i.e., 4-20 mA / 0-10 Volts etc. The sensing range required shall be 0-2000 PPM with good resolution.
 - The preferred type of sensing element / method is NDIR type with accuracy of +/-30PPM or +/-5% of measured value. Warm up time of sensor shall be <2 minutes & response time is better than 150 seconds.
 - Sensor shall be suitable to fix & operate at 1500 to 1750mm above the finished floor level.
- **Water Level Sensor**
 - Type : Float /Capacitance /Conductivity
 - Mounting : To suit application.
 - Connection : Flanged ANSI 150 lbs RF Carbon steel
 - Float material : 316 SS
 - Stem Material : 316 SS
 - Output : 4 – 20 mA
 - Enclosure : IP 68

1.6.26 Enclosures for DDC Panel

- All the controllers shall be housed in Lockable Vandal proof boxes which shall either be floor mounted or wall mounted. These shall be free standing, totally enclosed, dust and vermin proof and suitable for tropical climatic conditions.
- The panel shall be metal enclosed 18 SWG CRCA sheet steel cubicle with gaskets between all adjacent units and beneath all covers to render the joints dust proof. All doors and covers shall be hinged and latched and shall be folded and braced as necessary to provide a rigid support. Joints of any kind in sheet metal shall be seam welded with welding slag grounded off and welding pits wiped smooth with plumber metal.
- All panels and covers shall be properly fitted and secured with the frame and holes in the panels correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with nuts. Self-threading screws shall

not be used in the construction of control panels. Knockout holes of approved size and number shall be provided in the panels in conformity with the location of incoming and outgoing conduits/cables. Lamps shall be provided to support the weight of the cables. The dimension of the boxes shall depend on the requirement with the colour decided in consultation with the Architect/Consultant.

- Note: All panel enclosures used in plant room spaces and external to building shall be suitable for outdoor application (IP 66 protection).

1.6.27 Cable, Wiring & Conduits

- The latest IS standards & codes, rules shall be applicable for all conduits & cabling. Control and interlock wiring and installation shall comply with national and local electrical codes.
- **Cables**
 - All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 Volt
Communications	Per Mfr.	Per Mfr.

- Cables shall meet the signal cabling requirement of the system manufacturer.
- Fiber optic cable shall include the following sizes: 50/125, 62.5/125 or 100/140.
- Only glass fiber is acceptable, no plastic.
- Fiber optic cable shall only be installed and terminated by an experienced contractor. (The MSI shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.)
- The cable shall meet minimum the following requirements:
 - ✓ Cables used shall be Armoured/ Flexible cables.
 - ✓ Cables used shall have minimum 98% conductivity copper.
 - ✓ Minimum 16 twists/m should be present for twisted pair cables.
 - ✓ Minimum sheath thickness should be 0.90mm or greater and PVC material.
 - ✓ Minimum 2 Core, 4core, 6 core cable connecting the Field devices to DDCs shall be PVC insulated copper, multi strand,
 - ✓ Shielded cables shall be minimum 1100V grades and shall generally confirm to latest IS standards and meet the signal cabling requirement of the system manufacturer.
 - ✓ For Analog IO"s, Digital input Screened cables should be used.
 - ✓ For Digital output, power cables - unscreened cables can be used.
 - ✓ For shorter distance 1.0sq.mm cable and for longer distance 1.5sq.mm cables should be used.
 - ✓ Minimum 2 core twisted pair screened cable of 18AWG should be used for third party integrations/communication in order to avoid Electromagnetic interference (EMI).
 - ✓ Cables from List of Makes to be proposed based on system architecture and site conditions assuring high level of reliability.
 - ✓ The cable shall be manufacturer tested as per the latest IS standards.

- ✓ The signal cable shall be of the following specifications:
 - ❖ Type of Conductor : Shielded ATC Conductor
 - ❖ Size : 1 sq. mm
 - ❖ Insulation Material : Polyethylene /PVC
 - ❖ Shielding : Overall beld foil Aluminium polyester shield.
 - ❖ Jacket : Chrome PVC
 - ❖ Nominal DCR : 17.6 ohm/km for conductor, 57.0 ohm/km for shield
 - ❖ Nominal OD : 8.5 mm
 - ❖ Nominal capacitance : 130 pF/m between conductors at 1 KHz, 180 pF/m between one conductor and other conductors connected to shield.
 - ❖ Outer Sheath Material : FRLS
 - ❖ Screened/Unscreened : Screened
 - ❖ Shielded/Unshielded : Shielded
 - ❖ Armoured/Un-armoured : Armoured
 - ❖ Colour : Black and Red, Black, and White
- ✓ Communication cables for Third Party Integration shall have the below spes:
 - ❖ Type of Conductor : Shielded ATC Conductor
 - ❖ Copper Size of Conductor : 1.5 Sq. mm.
 - ❖ Insulation Material : Polyethylene /PVC
 - ❖ Shielding : Overall beld foil Aluminium polyester shield.
 - ❖ Jacket : Chrome PVC
 - ❖ Nominal DCR : 78.7 ohm/km for conductor, 55.8 ohm/km for Shield
 - ❖ Nominal capacitance : 131 pF/m between conductors at 1 KHz, 243 pF/m between one conductor and other conductors connected to shield.
 - ❖ Outer Sheath Material : FRLS
 - ❖ Screened/Unscreened : Screened
 - ❖ Shielded/Unshielded : Shielded
 - ❖ Armoured/Unarmoured : Armoured
 - ❖ Colour : Black and Red, Black and White

Note: The Communication cables shall be shielded and grounded properly

- **Conduits**

- Conduits and accessories shall conform to relevant Indian Standards. PVC conduits shall be with a minimum of 2 mm thick and of required diameter shall be used.
- Separate conduits shall run for all power wiring. Connections between conduit and controller metal boxes shall be by means of brass hexagon smooth bore bush, fixed inside the box and connected through a coupler to the conduit. The joints in conduits shall be smooth to avoid damage to insulation of conductors while pulling them through the conduits. Where necessary, bends or diversions may be achieved by means of bends or circular inspection boxes

with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction box shall be provided with a cover properly secured and flush with a finished wall surface. No bends shall have radius less than 2.5 times the outside diameter of the conduit.

- **Cable Trays**

- The tray shall be shop fabricated and shall be free from burr and sharp edges.
- The cable trays M.S. Material used shall confirm to IS-2062 & Galvanizing shall confirm to IS-2629. The Zinc coating shall confirm to IS-4759.
- Width of ladder shall be 100mm to 1000mm as per requirement, length shall be 2.5mtr and depth shall be 50mm. Thickness of the tray shall be 1.6 mm.
- The trays shall be powder coated GI tray with cover and shall have support rods and brackets at regular intervals to fix the cables in position with necessary accessories like bends, couplers etc.
- The fire partitions penetrations by cable trays shall be protected by approved sealing methods, maintaining the same fire resistance rating as the partition.
- Fire sealant shall be provided to cover all gaps around the Cable trays routed through partitions / walls.

1.6.28 BMS IO Data Summary

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
I	DDC CONTROLLERS							
A	DDC ID - 01							
	Location of DDC Panel: Under Ground Pump Room							
1	Main Electric (Hydrant) Pump	1						
	Pump ON / OFF Status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	Main Electric (Sprinkler) Pump	1						

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Pump ON / OFF Status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	Jockey Pump	2						
	Pump ON / OFF Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Diesel Generator Pump	1						
	Pump ON / OFF Status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			1				230 V, 6A Relay. Termination to the MCC panel

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
	Battery Charger Monitoring	1	1					Battery Charger
	Fuel Tank Level Monitoring	1	1					Level Sensor
5	Booster Pump	1						
	Pump ON / OFF Status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
6	Firefighting MCC Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	10		10				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	10		10				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
7	Fire Tank Level							

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Basement Floor - Level Monitoring (Low / High)	2		2				Level Switch
	Terrace Floor - Level Monitoring (Low / High)	1		1				Level Switch
8	Pump Room Exhaust fan	1						
	Fans On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
9	Fresh Air Axial fan	1						
	Fans On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
	Total		2	51	0	2	0	
	Spare		1	11	1	1		
	Total including spares for DDC ID - 01		3	62	1	3	0	
B	DDC ID - 02							
	Location of DDC Panel: Under Ground Pump Room							
1	Domestic Transfer Pump	3						
	Pump ON / OFF Status			3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	Flushing Transfer Pump	3						
	Pump ON / OFF Status			3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Pump Auto / Manual Status			3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	HVAC Make-up Water Transfer Pump	3						
	Pump ON / OFF Status			3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Rain Water Overflow Pump	2						
	Pump ON / OFF Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
5	Irrigation Pump	2						
	Pump ON / OFF Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Pump Trip Status.			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
6	Domestic Booster Pump	2						
	Pump ON / OFF Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
7	Flushing Booster Pump	2						
	Pump ON / OFF Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
8	Dewatering Pump	2						

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Pump ON / OFF Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
9	UGT Filling Irrigation Transfer Pump	2						
	Pump ON / OFF Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
10	UGT Filling Flushing Transfer Pump	2						
	Pump ON / OFF Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
11	UGT Filling HVAC Make-up Transfer Pump	2						
	Pump ON / OFF Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Trip Status.			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Pump Auto / Manual Status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
12	PHE MCC Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	25		25				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	25		25				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
13	Tank Level							
	Basement Floor - Level Monitoring (Low / High)	9		9				Level Switch

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Terrace Floor - Level Monitoring (Low / High)	5		5				Level Switch
	Total		0	141	0	0	0	
	Spare		1	29	1	1		
	Total including spares DDC ID - 02		1	170	1	1	0	
C	DDC ID - 03							
	Location of DDC Panel: Ground Floor HT Panel / Transformer Room							
1	HT Panel 01							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	3		3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	3		3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	DG Synchronous Panel 01							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Synchronous Relay Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	3		3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	3		3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	DG Synchronous Panel 02							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Synchronous Relay Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	3		3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	3		3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
4	HT Panel / Transformer Room & DG Room Exhaust Fan	2						
	Fan On / Off Command					2		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fan On / Off status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fan Auto / Manual status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fan Trip status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
5	HT Panel / Transformer Room & DG Room Fresh Air Fan	8						
	Fan On / Off Command					8		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fan On / Off status			8				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fan Auto / Manual status			8				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fan Trip status			8				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Total		0	62	0	10	0	
	Spare		1	13	1	2		
	Total including spares DDC ID - 03		1	75	1	12	0	
D	DDC ID - 04							
	Location of DDC Panel: Ground Floor Chiller Plant Room							
1	Outside Air RH & Temperature.		2					Ambient type RH & Temperature sensors
2	Ambient Co2 Level		1					Ambient type Co2 Sensor
3	Chiller Plant Room Exhaust Fan	2						
	Fan On / Off Command					2		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fan On / Off status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fan Auto / Manual status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fan Trip status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	HVAC Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	13		13				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	13		13				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Total		3	34	0	2	0	
	Spare		1	7	1	1		
	Total including spares DDC ID - 04		4	41	1	3	0	
E	DDC ID - 05							
	Location of DDC Panel: Ground Floor HUB Room							
1	Main Power Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	9		9				230 V, 6A Relay. Termination to the MCC panel

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
	Outgoing Breaker Trip Status	9		9				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	Common Area Power Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	18		18				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	18		18				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	Common Area Lighting Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	22		22				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Outgoing Breaker Trip Status	22		22				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Ceiling Suspended Unit (CSU)	5						
	CSU On / Off command							
	CSU On / Off status							
	CSU Auto / Manual status							
	CSU Trip status							
	Return air Temperature & RH		10					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		5					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		5		5			2 Way PIBCV valve
	Fire Damper status			5				
	Filter status			10				DP Switch
	Chilled water inlet & outlet temperature		10					Immersion type temperature sensor
	Return air CO2 Level		5					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		5		5			Modulating type damper actuator
	Duct static pressure feedback		5					Static pressure sensor - Duct Type
	Air velocity Sensor		5					Velocity Sensor
	UV Lamp Status Monitoring			5				Voltage free contact from

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								AHU Starter Panel
	Total		50	126	10	0	0	
	Spare		10	27	2	1		
	Total including spares DDC ID - 05		60	153	12	1	0	
F	DDC ID - 06							
	Location of DDC Panel: First Floor LT Panel Room							
1	LT Panel 01							
	Incomer Breaker On / Off Status (From secondary side of Transformer)	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status (From secondary side of Transformer)	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker On / Off Status (From DG Synchronizing panel)	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status (From DG Synchronizing panel)	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	15		15				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	15		15				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Bus Coupler On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Bus Coupler Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	LT Panel 02							
	Incomer Breaker On / Off Status (From secondary side of Transformer)	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status (From secondary side of Transformer)	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker On / Off Status (From DG Synchronizing panel)	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status (From DG Synchronizing panel)	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	15		15				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	15		15				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Bus Coupler On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Bus Coupler Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	LT Panel 03							
	Incomer Breaker On / Off Status (From secondary side of Transformer)	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status (From secondary side of Transformer)	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	APFCR Panel 01							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	APFC Relay Monitor	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
5	APFCR Panel 02							

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	APFC Relay Monitor	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
6	APFCR Panel 03							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	APFC Relay Monitor	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
7	APFCR Panel 04							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	APFC Relay Monitor	11		11				230 V, 6A Relay. Termination to the MCC panel

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
	Total		0	136	0	0	0	
	Spare		1	28	1	1		
	Total including spares DDC ID - 06		1	164	1	1	0	
G	DDC ID - 07							
	Location of DDC Panel: First Floor LT Panel Room							
1	UPS Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	4		4				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	4		4				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	Utility Panel							
	Incomer Breaker On / Off Status	3		3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	3		3				230 V, 6A Relay. Termination to

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	Fire Emergency Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	6		6				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	6		6				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Fresh Air Axial fan	1						
	Fans On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Fans Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
5	Exhaust fan	1						
	Fans On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Total		0	62	0	2	0	
	Spare		1	15	1	1		
	Total including spares DDC ID - 07		1	77	1	3	0	
H	DDC ID - 08							
	Location of DDC Panel: First Floor Electrical Room							

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
1	Main Power Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	HVAC Power Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	16		16				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	16		16				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Total		0	60	0	0	0	

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Spare		1	12	1	1		
	Total including spares DDC ID - 08		1	72	1	1	0	
I	DDC ID - 09							
	Location of DDC Panel: First Floor HUB Room							
1	Ceiling Suspended Unit (CSU)	3						
	CSU On / Off command							
	CSU On / Off status							
	CSU Auto / Manual status							
	CSU Trip status							
	Return air Temperature & RH		6					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		3					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		3		3			2 Way PIBCV valve
	Fire Damper status			3				
	Filter status			6				DP Switch
	Chilled water inlet & outlet temperature		6					Immersion type temperature sensor
	Return air CO2 Level		3					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		3		3			Modulating type damper actuator

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Duct static pressure feedback		3					Static pressure sensor - Duct Type
	Air velocity Sensor		3					Velocity Sensor
	UV Lamp Status Monitoring			3				Voltage free contact from AHU Starter Panel
2	Air Handling Unit (AHU) - For Entrance Foyer Lobby (Mezzanine Floor)	1						
	AHU On / Off command							
	AHU On / Off status							
	AHU Auto / Manual status							
	AHU Trip status							
	Return air Temperature & RH		6					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		3					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		3		3			2 Way PIBCV valve
	Fire Damper status			3				
	Filter status			6				DP Switch
	Chilled water inlet & outlet temperature		6					Immersion type temperature sensor
	Return air CO2 Level		3					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		3		3			Modulating type damper actuator

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Duct static pressure feedback		3					Static pressure sensor - Duct Type
	Air velocity Sensor		3					Velocity Sensor
	UV Lamp Status Monitoring			3				Voltage free contact from AHU Starter Panel
	Total		60	24	12	0	0	
	Spare		12	5	3	1		
	Total including spares DDC ID - 09		72	29	15	1	0	
J	DDC ID - 10							
	Location of DDC Panel: Second Floor HUB Room							
1	Main Power Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	HVAC Power Panel							

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	15		15				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	15		15				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	Cafeteria Power Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	7		7				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	7		7				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Ceiling Suspended Unit (CSU)	1						
	CSU On / Off command							

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	CSU On / Off status							
	CSU Auto / Manual status							
	CSU Trip status							
	Return air Temperature & RH		2					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		1					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		1		1			2 Way PIBCV valve
	Fire Damper status			1				
	Filter status			2				DP Switch
	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor
	Return air CO2 Level		1					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		1		1			Modulating type damper actuator
	Duct static pressure feedback		1					Static pressure sensor - Duct Type
	Air velocity Sensor		1					Velocity Sensor
	UV Lamp Status Monitoring			1				Voltage free contact from AHU Starter Panel
	Total		10	80	2	0	0	
	Spare		2	13	1	1		
	Total including spares DDC ID - 10		12	93	3	1	0	

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
K	DDC ID - 11							
	Location of DDC Panel: Second Floor Cafeteria							
1	Ceiling Suspended Unit (CSU)	4						
	CSU On / Off command							
	CSU On / Off status							
	CSU Auto / Manual status							
	CSU Trip status							
	Return air Temperature & RH		8					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		4					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		4		4			2 Way PIBCV valve
	Fire Damper status			4				
	Filter status			8				DP Switch
	Chilled water inlet & outlet temperature		8					Immersion type temperature sensor
	Return air CO2 Level		4					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		4		4			Modulating type damper actuator
	Duct static pressure feedback		4					Static pressure sensor - Duct Type
	Air velocity Sensor		4					Velocity Sensor
	UV Lamp Status Monitoring			4				Voltage free contact from

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								AHU Starter Panel
	Total		40	16	8	0	0	
	Spare		8	4	2	1		
	Total including spares DDC ID - 11		48	20	10	1	0	
L	DDC ID - 12							
	Location of DDC Panel: Second Floor Cafeteria							
1	Ceiling Suspended Unit (CSU)	2						
	CSU On / Off command							
	CSU On / Off status							
	CSU Auto / Manual status							
	CSU Trip status							
	Return air Temperature & RH		4					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		2					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		2		2			2 Way PIBCV valve
	Fire Damper status			2				
	Filter status			4				DP Switch
	Chilled water inlet & outlet temperature		4					Immersion type temperature sensor

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Return air CO2 Level		2					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		2		2			Modulating type damper actuator
	Duct static pressure feedback		2					Static pressure sensor - Duct Type
	Air velocity Sensor		2					Velocity Sensor
	UV Lamp Status Monitoring			2				Voltage free contact from AHU Starter Panel
	Total		20	8	4	0	0	
	Spare		4	2	1	1		
	Total including spares DDC ID - 12		24	10	5	1	0	
M	DDC ID - 13							
	Location of DDC Panel: Second Floor HUB Room							
1	Ceiling Suspended Unit (CSU)	4						
	CSU On / Off command							
	CSU On / Off status							
	CSU Auto / Manual status							
	CSU Trip status							
	Return air Temperature & RH		8					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		4					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum		4		4			2 Way PIBCV valve

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Control Valve (PIBCV) Valve control & status							
	Fire Damper status			4				
	Filter status			8				DP Switch
	Chilled water inlet & outlet temperature		8					Immersion type temperature sensor
	Return air CO2 Level		4					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		4		4			Modulating type damper actuator
	Duct static pressure feedback		4					Static pressure sensor - Duct Type
	Air velocity Sensor		4					Velocity Sensor
	UV Lamp Status Monitoring			4				Voltage free contact from AHU Starter Panel
	Total		40	16	8	0	0	
	Spare		14	6	3	1		
	Total including spares DDC ID - 13		54	22	11	1	0	
N	DDC ID - 14							
	Location of DDC Panel: Second Floor HUB Room							
1	Ceiling Suspended Unit (CSU)	3						
	CSU On / Off command							
	CSU On / Off status							
	CSU Auto / Manual status							

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	CSU Trip status							
	Return air Temperature & RH		6					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		3					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		3		3			2 Way PIBCV valve
	Fire Damper status			3				
	Filter status			6				DP Switch
	Chilled water inlet & outlet temperature		6					Immersion type temperature sensor
	Return air CO2 Level		3					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		3		3			Modulating type damper actuator
	Duct static pressure feedback		3					Static pressure sensor - Duct Type
	Air velocity Sensor		3					Velocity Sensor
	UV Lamp Status Monitoring			3				Voltage free contact from AHU Starter Panel
	Total		30	12	6	0	0	
	Spare		6	4	2	1		
	Total including spares DDC ID - 14		36	16	8	1	0	
O	DDC ID - 15 - TYPICAL (3RD, 4TH, 6TH & 7TH FLOOR)							

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Location of DDC Panel: HUB Room							
1	Main Power Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	13		13				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	13		13				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	HVAC Power Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	16		16				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	16		16				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
3	Ceiling Suspended Unit (CSU)	1						
	CSU On / Off command							
	CSU On / Off status							
	CSU Auto / Manual status							
	CSU Trip status							
	Return air Temperature & RH		2					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		1					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		1		1			2 Way PIBCV valve
	Fire Damper status			1				
	Filter status			2				DP Switch
	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor
	Return air CO2 Level		1					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		1		1			Modulating type damper actuator
	Duct static pressure feedback		1					Static pressure sensor - Duct Type
	Air velocity Sensor		1					Velocity Sensor
	UV Lamp Status Monitoring			1				Voltage free contact from AHU Starter Panel
	Total		10	68	2	0	0	
	Spare		2	13	1	1		

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Total including spares DDC ID - 15		12	81	3	1	0	
	Total IO Count For 4 Sets of DDC		48	324	12	4	0	
P	DDC ID - 16 - 5TH FLOOR							
	Location of DDC Panel: HUB Room							
1	Main Power Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	HVAC Power Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Outgoing Breaker On / Off Status	9		9				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	9		9				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	Ceiling Suspended Unit (CSU)	1						
	CSU On / Off command							
	CSU On / Off status							
	CSU Auto / Manual status							
	CSU Trip status							
	Return air Temperature & RH		2					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		1					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		1		1			2 Way PIBCV valve
	Fire Damper status			1				
	Filter status			2				DP Switch
	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor
	Return air CO2 Level		1					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		1		1			Modulating type damper actuator
	Duct static pressure feedback		1					Static pressure sensor - Duct Type

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Air velocity Sensor		1					Velocity Sensor
	UV Lamp Status Monitoring			1				Voltage free contact from AHU Starter Panel
	Total		10	50	2	0	0	
	Spare		2	10	1	1		
	Total including spares DDC ID - 16		12	60	3	1	0	
Q	DDC ID - 17 - TYPICAL (8TH, 9TH, 10TH, 11TH & 12TH FLOOR)							
	Location of DDC Panel: HUB Room							
1	Main Power Panel							
	Incomer Breaker On / Off Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	2		2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	11		11				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	HVAC Power Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	9		9				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	9		9				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	Ceiling Suspended Unit (CSU)	1						
	CSU On / Off command							
	CSU On / Off status							
	CSU Auto / Manual status							
	CSU Trip status							
	Return air Temperature & RH		2					Duct type Temperature and duct type Rh sensors
	Supply Air Temperature		1					Supply air temperature sensor - Duct Type
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		1		1			2 Way PIBCV valve
	Fire Damper status			1				
	Filter status			2				DP Switch
	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Return air CO2 Level		1					Duct CO2 sensor
	Fresh Air Modulating Damper control & Status		1		1			Modulating type damper actuator
	Duct static pressure feedback		1					Static pressure sensor - Duct Type
	Air velocity Sensor		1					Velocity Sensor
	UV Lamp Status Monitoring			1				Voltage free contact from AHU Starter Panel
	Total		10	50	2	0	0	
	Spare		2	10	1	1		
	Total including spares DDC ID - 17		12	60	3	1	0	
	Total IO Count For 5 Sets of DDC		60	300	15	5	0	
R	DDC ID - 18 - TYPICAL 2AHU IN 1 DDC (3RD FLOOR - 7TH FLOOR AHU ROOM)	2						
	Location of DDC Panel: AHU Room							
1	AHU On / Off command							
2	AHU On / Off status							
3	AHU Auto / Manual status							
4	AHU Trip status							
5	Return air Temperature & RH		4					Duct type Temperature and duct type Rh sensors
6	Supply Air Temperature		2					Supply air temperature

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								sensor - Duct Type
7	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		2		2			2 Way PIBCV valve
8	Fire Damper status			2				
9	Filter status			4				DP Switch
10	Chilled water inlet & outlet temperature		4					Immersion type temperature sensor
11	Return air CO2 Level		2					Duct CO2 sensor
12	Fresh Air Modulating Damper control & Status		2		2			Modulating type damper actuator
13	Duct static pressure feedback		2					Static pressure sensor - Duct Type
14	Air velocity Sensor		2					Velocity Sensor
15	UV Lamp Status Monitoring			2				Voltage free contact from AHU Starter Panel
	Total		20	8	4	0	0	
	Spare		4	2	2	1		
	Total including spares DDC ID - 18		24	10	6	1	0	
	Total including spares for Total 19 Nos of AHU		480	200	120	20	0	
S	DDC ID - 19 - TYPICAL 1 AHU IN 1 DDC (8TH FLOOR - 12TH FLOOR AHU ROOM)	1						
	Location of DDC Panel: AHU Room							

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
1	AHU On / Off command							
2	AHU On / Off status							
3	AHU Auto / Manual status							
4	AHU Trip status							
5	Return air Temperature & RH		2					Duct type Temperature and duct type Rh sensors
6	Supply Air Temperature		1					Supply air temperature sensor - Duct Type
7	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		1		1			2 Way PIBCV valve
8	Fire Damper status			1				
9	Filter status			2				DP Switch
10	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor
11	Return air CO2 Level		1					Duct CO2 sensor
12	Fresh Air Modulating Damper control & Status		1		1			Modulating type damper actuator
13	Duct static pressure feedback		1					Static pressure sensor - Duct Type
14	Air velocity Sensor		1					Velocity Sensor
15	UV Lamp Status Monitoring			1				Voltage free contact from AHU Starter Panel
	Total		10	4	2	0	0	
	Spare		2	1	1	1		
	Total including spares DDC ID - 19		12	5	3	1	0	

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Total including spares for Total 21 Nos of AHU		240	100	60	20	0	
T	DDC ID - 20	1						
	Location of DDC Panel: IP 67 Outdoor Type Enclosures							
1	Cooling tower basin level low	4	4					Level Switch
2	Cooling tower basin level high	4	4					Level Switch
3	Air Cooled Chiller Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	9		9				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	9		9				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Cooling Tower Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
	Outgoing Breaker On / Off Status	9		9				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	9		9				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Total		8	40	0	0	0	
	Spare		2	3	2	2		
	Total including spares DDC ID - 20		10	43	2	2	0	
U	DDC ID - 21	1						
	Location of DDC Panel: IP 67 Outdoor Type Enclosures							
1	Fresh Air Fans (TFA) (Fresh Air Fan (TFA - 01 Nos) + Smoke Fresh Air Fan (TFA - 01 Nos))	2						
	Fans On / Off Command					2		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			2				DP Switch
	Fans Auto / Manual status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			2				230 V, 6A Relay. Termination to the MCC panel

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
	VFD speed control				2			230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	VFD speed feedback		2					230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Duct static pressure feedback		2					Static pressure sensor - Duct Type
	Chilled water inlet & outlet temperature		4					Immersion type temperature sensor
	Supply Air Temperature		2					Duct Temperature in the outlet
	PIBCV Valve control & status		2		2			2 Way PIBCV valve
	Filter status			4				OD DP Switch
2	Heat Recovery Wheel Unit (HRW)	1						
	Fans On / Off Command					2		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			2				DP Switch
	Fans Auto / Manual status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	EC Fan Speed control				1			

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	EC Fan Speed feedback		1					
	Duct static pressure feedback		1					Static pressure sensor - Duct Type
	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor
	Supply Air Temperature		1					Duct Temperature in the outlet
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		1		1			2 Way PIBCV valve
	Filter status			2				OD DP Switch
3	Pressurization (Service Lift well - 1, Main Lift Lobby - 1, Main Lift well - 3 & Staircase - 1)	6						
	Fans On / Off status			6				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			6				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			6				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Smoke Exhaust fan	1						
	Fans On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			1				230 V, 6A Relay. Termination to the MCC panel

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
	Fans Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Total		18	39	6	5	0	
	Spare		4	8	2	1		
	Total including spares DDC ID - 21		22	47	8	6	0	
V	DDC ID - 22	1						
	Location of DDC Panel: IP 67 Outdoor Type Enclosures							
1	Fresh Air Fans (TFA)	1						
	Fans On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			1				DP Switch
	Fans Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	VFD speed control				1			230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	VFD speed feedback		1					230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Duct static pressure feedback		1					Static pressure sensor - Duct Type
	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor
	Supply Air Temperature		1					Duct Temperature in the outlet
	PIBCV Valve control & status		1		1			2 Way PIBCV valve
	Filter status			2				OD DP Switch
2	Heat Recovery Wheel Unit (HRW)	1						
	Fans On / Off Command					2		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			2				DP Switch
	Fans Auto / Manual status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	EC Fan Speed control				1			230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	EC Fan Speed feedback		1					230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Duct static pressure feedback		1					Static pressure sensor - Duct Type
	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor
	Supply Air Temperature		1					Duct Temperature in the outlet
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		1		1			2 Way PIBCV valve
	Filter status			2				OD DP Switch
3	Pressurization (Main Lift well - 2, Main Lift Lobby - 1, Kitchen Ventilation - 1, & Service Lift Lobby - 1)	5						
	Fans On / Off status			5				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			5				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			5				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Electrical Room Exhaust fan	2						
	Fans On / Off Command					2		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Fans On / Off status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Total		12	34	4	5	0	
	Spare		3	7	1	1		
	Total including spares DDC ID - 22		15	41	5	6	0	
W	DDC ID - 23	1						
	Location of DDC Panel: IP 67 Outdoor Type Enclosures							
1	Heat Recovery Wheel Unit (HRW)	1						
	Fans On / Off Command					2		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			2				DP Switch
	Fans Auto / Manual status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			2				230 V, 6A Relay. Termination to the MCC panel

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
	EC Fan Speed control				1			230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	EC Fan Speed feedback		1					230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Duct static pressure feedback		1					Static pressure sensor - Duct Type
	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor
	Supply Air Temperature		1					Duct Temperature in the outlet
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		1		1			2 Way PIBCV valve
	Filter status			2				OD DP Switch
2	Pressurization (Main Lift well - 2, Main Lift Lobby - 1, Kitchen Ventilation - 1, Staircase - 1 & Service Lift Lobby - 1)	6						
	Fans On / Off status			6				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			6				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			6				230 V, 6A Relay. Termination to the MCC panel

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
3	Kitchen Exhaust fan	1						
	Fans On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Dry Scrubber	5						
	Fans On / Off Command					5		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			5				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			5				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			5				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Total		6	44	2	8	0	
	Spare		2	9	1	2		
	Total including spares DDC ID - 23		8	53	3	10	0	
X	DDC ID - 24	1						
	Location of DDC Panel: IP 67 Outdoor Type Enclosures							
1	Heat Recovery Wheel Unit (HRW)	1						
	Fans On / Off Command					2		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			2				DP Switch
	Fans Auto / Manual status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	EC Fan Speed control				1			230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	EC Fan Speed feedback		1					230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Duct static pressure feedback		1					Static pressure sensor - Duct Type

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Chilled water inlet & outlet temperature		2					Immersion type temperature sensor
	Supply Air Temperature		1					Duct Temperature in the outlet
	Pressure Independent Balancing cum Control Valve (PIBCV) Valve control & status		1		1			2 Way PIBCV valve
	Filter status			2				OD DP Switch
2	Pressurization (Main Lift well - 3, Main Lift Lobby - 1, & Service Lift well - 1)	5						
	Fans On / Off status			5				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			5				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			5				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	Smoke Exhaust fan	2						
	Fans On / Off Command					2		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			2				230 V, 6A Relay. Termination to the MCC panel

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
	Fans Trip status			2				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Total		6	29	2	4	0	
	Spare		2	6	1	1		
	Total including spares DDC ID - 24		8	35	3	5	0	
Y	DDC ID - 25							
	Location of DDC Panel: IP 67 Outdoor Type Enclosures							
1	Ventilation Fan Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	25		25				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	25		25				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	Elevator Panel							

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	14		14				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	14		14				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	Pressurization Fan Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	23		23				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	23		23				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Total		0	130	0	0	0	
	Spare		1	30	1	1		

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Total including spares DDC ID - 25		1	160	1	1	0	
Z	DDC ID - 26							
	Location of DDC Panel: STP Plant Room							
1	HT Panel 02							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	3		3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker Trip Status	3		3				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
2	STP & SWM Area Ventilation Fan Panel							
	Incomer Breaker On / Off Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Incomer Breaker Trip Status	1		1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Outgoing Breaker On / Off Status	6		6				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
	Outgoing Breaker Trip Status	6		6				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
3	Ozone Generator	1						
	On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	On / Off Status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Trip' status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
4	Fresh Air Axial fan	1						
	Fans On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			1				230 V, 6A Relay. Termination to the MCC panel

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
								upto NO Contact.
5	Exhaust fan	1						
	Fans On / Off Command					1		230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans On / Off status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Auto / Manual status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Fans Trip status			1				230 V, 6A Relay. Termination to the MCC panel upto NO Contact.
	Total		0	31	0	3	0	
	Spare		1	7	1	1		
	Total including spares DDC ID - 26		1	38	1	4	0	
II	THIRD PARTY INTEGRATIONS							
1	Electrical Multifunction Meters	550					5500	
2	BTU Meter Integration	150					750	
3	DG Synchronous Panel PLC integration	1					200	
4	UPS	2					30	
5	Secondary Pump PLC panel	2					150	
6	EC Fan	120					1200	

SL. No	DESCRIPTION	QTY	AI	DI	AO	DO	Soft Points	Required Field Devices
7	VFD	15					150	
8	Fire Alarm Panels	1					6500	
9	Water Meter Integration	65					325	
10	CHW Cassette Units Integration	30					300	
11	Elevator monitoring system(Lifts)	12					120	
12	Chiller Plant Manager (Water Cooled)	1					200	
13	Chiller Plant Manager (Air Cooled)	1					100	
14	Solar System Panel Integration	1					100	
15	EV Charging Station Integration	60					600	
16	HSD Tank Flow Monitor Integration	2					20	
17	HSD Tank Consumption Meter Integration	2					20	
18	PHE Pump PLC panel integration	1					100	
19	Transformer Integration	3					60	
20	HT Panel PLC System Integration	3					300	
21	Thermostat integration	40					400	
22	VAV Integration	10					100	
23	PAC Integration	2					20	
24	Perimeter Intrusion Detection System	15					75	
	TOTAL IO POINTS 3rd PARTY INTEGRATION						17320	
	TOTAL POINTS		922	2207	230	92	17320	

1.7 Data Networking & Telecom Services - ICT**1.7.1 Technical Specifications of Network Switches****24 port Core Switch**

S. No.	Technical Parameters / Specification	Compliance (Yes/No)
1	The Switch should support line rate & non-blocking Layer 2 switching and Layer 3 routing	
2	There switch should not have any single point of failure like power supplies and fans etc should have 1:1/N+1 level of redundancy and must be hot swappable.	
3	Switch should support the complete STACK of IP V4 and IP V6 services.	
4	Switch should have the following interfaces: 24 x 1/10G SFP port populated with 8 x 10G LR transceivers and 16 x 1G BaseT transceivers	
5	Switch should support IEEE Link Aggregation for redundancy across two switches in active- active mode	
6	The switch should support 250k IPv4 routes or above	
7	The switch should support hardware-based load balancing at wire speed using LACP and multi chassis ether channel/LAG	
8	Switch should support minimum 2.5 Tbps of throughput capacity	
9	Switch should support minimum 208,000 no. of MAC addresses	
10	Switch should support Jumbo Frames up to 9K Bytes on all Ports	
11	Support storm control to prevent degradation of switch performance from storm due to network attacks and vulnerabilities	
12	Switch should support Policy Based Routing	
13	Switch should provide multicast traffic reachable using:	
a	PIM-SM	
b	PIM-SSM	
c	Support RFC 3618 Multicast Source Discovery Protocol (MSDP)	
d	IGMP V.2 and V.3	
14	Switch should support Multicast routing	
15	Switch should support for BFD For Fast Failure Detection	
16	Switch should support Routing Protocols: OSPFv2 with multiple instances, OSPFv3, BGP, MP-BGP, IS-IS, and RIPv2	
17	Switch should support VXLAN with EVPN control plane	
18	Switch must support symmetric/asymmetric VXLAN integrated routing and bridging with EVPN active- active multihoming support.	

S. No.	Technical Parameters / Specification	Compliance (Yes/No)
19	Should support 8 queues per port, priority queuing, round-robin queuing	
20	Should support QoS classification, policing and shaping, DSCP and COS.	
21	Should support WRED, Explicit Congestion Notification, priority flow control, data center bridging.	
22	Switch should support control plane i.e. processor and memory Protection from unnecessary or DoS traffic by control plane protection policy	
23	Switch should support for external database for AAA using:	
a	a. TACACS+	
b	b. RADIUS	
24	Switch should support for Role Based access control (RBAC) for restricting host level network access as per policy defined	
25	Switch should support MAC ACLs	
26	Should support Standard & Extended ACLs using L2, L3 and L4 fields	
27	Switch should support minimum IEEE 1588 PTP boundary clock mode	
28	Should support telnet, ssh, https, SNMPv3, TWAMP, event manager, scheduler and configuration rollback for ease of operations and management	
29	Switch should support onboard Packet Capture using Wireshark/tcpdump in real time for traffic analysis and fault finding	
30	All relevant licenses for all the above features and scale should be quoted along with switch	
31	Should have hot swappable and field replaceable internal redundant power supply and FAN from day one, should be provided with AC power supply and India power cords.	
32	All licenses should be provided with the devices for the mentioned features.	
33	All proposed switches except Industrial switches in the network should be able to run on same OS image and managed from single dashboard for simplified operations with minimal security exposure.	

S. No.	Technical Parameters / Specification	Compliance (Yes/No)
34	Visibility & Automation: Should be provided along with software for unified monitoring, provisioning, and telemetry solution from the same OEM. Should support telemetry with time-series database view, traffic flow analytics, PSIRT/BUG visibility, configuration compliance, endpoint tracking, POAP/ZTP, device resource utilization, auto topology view, alerts, Change workflow management, congestion monitoring, notification through email & msg, 3rd party integration. All Network switches (except Industrial switches) should be able to view and configured from a single dashboard. SI will factor required VM's to install the software in HA cluster, if any OEM wants to supply their Appliance, they allowed to in HA Cluster. All Network switches (except Industrial switches) should be managed from Single dashboard for simplified operations. All software should be onPrem, no Cloud solution is accepted.	
35	Device should be IPv6 Certified/IPv6 logo ready	
36	Device shall conform to UL 60950 or IEC 60950 or CSA 60950 or EN 60950 or EN 61000-3-3 Standards for Safety requirements of Information Technology Equipment.	
37	The Device should be EAL 3/NDPP/NDcPP certified under Common Criteria.	
38	All licences should be provided with the devices for the mentioned features. The licences should be perpetual in nature should be provided or 8 years from day-1 in case of subscription-based licencing. Hardware warranty 60 months from the Date of Installation Sign off. Confirmation on this need to be mentioned in signed MAF, any deviation will lead to rejection of Technical Bid.	
39	OEM & Bidder should not be from a country which shares a land border with India and Hardware should not be Manufactured & Assembled from a country which shares a land border with India. Same should be declared in MAF.	
40	All Network Switches should from Same OEM, for better support and no compatibility issue come up at later stage	
41	All Network Switches should run on same OS for simplified operations.	
42	All Network Switches quoted Models should have support life of 8 years minimum from the Date of delivery at Site, same need to be confirmed in signed MAF.	

S. No.	Technical Parameters / Specification	Compliance (Yes/No)
43	Bidder should submit fully complied solution, any deviation will result in bid rejection and Intentional wrong compliance claims will result in blacklisting of OEM & Bidder for next 3 years	
44	Specification mentioned are minimum required for critical network infrastructure, which is the backbone, any Bidder / OEM can quote higher specification with more advance features and with higher buffer, RAM, flash and processor cores	
45	Any deviation towards lower specification will result in rejection of the Technical Bid. Only Higher specification are accepted as part of technical bid	

24 Port PoE+ Edge / Distribution Switch

S. No.	Technical Parameters / Specification	Compliance Yes / No
1	Device should have 24 x 1G PoE+ Ports and 4 x 1/10G or better Uplink Ports in 1 RU fixed Form Factor, populated with 2 x 10G LR SFP supporting 10KM distance	
2	Device should have total Throughput of 128 Gbps.	
3	Device should support copper Base-T (1G & 10G) connectivity over CAT6 cable and 1G, Dual rate 1G/10G SFP+ fiber connectivity over MM and SM cable for the Uplink ports.	
4	Device should support upto 32K MAC address and 16K IPv4, 8k IPv6 host routes simultaneously	
5	Device should support upto 8K IPv4 and 2k IPv6 routes simultaneously	
6	The switch should support minimum of 30W (802.11at) on all 24 ports	
7	Device should have 1G management port, USB port and console port	
8	Device should support 4096 VLANs, 9216 Jumbo frame	
9	Device should support MST, per-vlan, RSTP, BPDU Guard, Loop Guard	
10	Device support LLDP, LLDP-MED and LACP to bundle links and detect miscabling issues.	
11	Device Should support IEEE 802.1D, 802.1Q, 802.1w, 802.1s, 802.3x and 802.1x and Q-in-Q	
12	Device should support Routing Protocols: OSPFv2 with multiple instances, OSPFv3, IS-IS, MP-BGP and RIPv2	
13	Device Should support Graceful restart for BGP, OSPF v2	
14	Device Should support BFD	

S. No.	Technical Parameters / Specification	Compliance Yes / No
15	Device Should support Policy Based Routing (PBR) for IPv4 and IPv6, VRRP V4 and V6, 32-way Equal Cost Multi-path Routing (ECMP), Unicast Reverse path forwarding (urpf)	
16	Should support GRE tunnel interface	
17	Device must support following ipv6 standard for network to be IPv6 ready.	
18	Device should support IGMP v2/v3, PIM-SM, Anycast RP (RFC 4610)	
19	Device should support VxLAN + EVPN	
20	Device should support Hitless upgrade & reloads in MLAG/Vpc setup.	
21	Switch should Provide constant PoE power even when switch is under maintenance or reload.	
22	Device should have N+1 redundant Fans	
23	Device should have N + 1 redundant power supply	
24	Should support Storm control and Control Plane protection (CPP)	
25	should support ACL with I2, L3 and L4 parameters upto 2K ingress and 512 Egress ACLs	
26	Device should support security-group based segmentation of hosts independent of the network constructs like VLAN, VRF and NVO.	
27	Device should support IEEE 802.1x Authentication framework, MAC authentication, Dynamic VLAN assignment, named VLAN assignment.	
28	Device should support priority between 802.1x and Mac based authentication	
29	Device Should support secure Zero touch provisioning with options to provision Certificates artifacts on the device when it boots.	
30	should support real time state streaming/ telemetry for advance monitoring from day 1	
31	Should Support industry standard hierarchical CLI, SSHv2, HTTPS, SCP, SFTP, CLI task scheduler and configuration session.	
32	should support NTP	
33	should support SNMP v1/2/3 and OpenConfig model over gRPC/Netconf	
34	Device should support Digital Optical Monitoring (DOM)	
35	Device should support real time data collection with sflow/netflow support.	
36	Device should support multiple simultaneous mirroring sessions across all ports.	

S. No.	Technical Parameters / Specification	Compliance Yes / No
37	should have programmability and automation support with on board python and bash	
38	should support 8 queues per port	
39	should support priority queue	
40	should support Weighted Fair Queue or Weighted round robin or equivalent	
41	should support ACL based classification for QoS	
42	Should support rate limiting function like policing and shaping	
43	All licenses should be provided with the devices for the mentioned features.	
44	All proposed switches except Industrial switches in the network should be able to run on same OS image and managed from single dashboard for simplified operations with minimal security exposure.	
45	Visibility & Automation: Should be provided along with software for unified monitoring, provisioning, and telemetry solution from the same OEM. Should support telemetry with time-series database view, traffic flow analytics, PSIRT/BUG visibility, configuration compliance, endpoint tracking, POAP/ZTP, device resource utilization, auto topology view, alerts, Change workflow management, congestion monitoring, notification through email & msg, 3rd party integration. All Network switches (except Industrial switches) should be able to view and configured from a single dashboard. SI will factor required VM's to install the software in HA cluster, if any OEM wants to supply their Appliance, they allowed to in HA Cluster. All Network switches should be managed from Single dashboard for simplified operations. All software should be onPrem, no Cloud solution is accepted.	
46	Device should be IPv6 Certified/IPv6 logo ready	
47	Device shall conform to UL 60950 or IEC 60950 or CSA 60950 or EN 60950 or EN 61000-3-3 Standards for Safety requirements of Information Technology Equipment.	
48	The Device should be EAL 3/NDPP/NDcPP certified under Common Criteria.	

S. No.	Technical Parameters / Specification	Compliance Yes / No
49	All licences should be provided with the devices for the mentioned features. The licences should be perpetual in nature should be provided or 8 years from day-1 in case of subscription-based licencing. Hardware warranty 60 months from the Date of Installation Sign off. Confirmation on this need to be mentioned in signed MAF, any deviation will lead to rejection of Technical Bid.	
50	OEM & Bidder should not be from a country which shares a land border with India and Hardware should not be Manufactured & Assembled from a country which shares a land border with India. Same should be declared in MAF.	
51	All Network Switches should from Same OEM, for better support and no compatibility issue come up at later stage	
52	All Network Switches should run on same OS for simplified operations.	
53	All Network Switches quoted Models should have support life of 8 years minimum from the Date of delivery at Site, same need to be confirmed in signed MAF.	
54	Bidder should submit fully complied solution, any deviation will result in bid rejection and Intentional wrong compliance claims will result in blacklisting of OEM & Bidder for next 3 years	
55	Specification mentioned are minimum required for critical network infrastructure, which is the backbone, any Bidder / OEM can quote higher specification with more advance features and with higher buffer, RAM, flash and processor cores	
56	Any deviation towards lower specification will result in rejection of the Technical Bid. Only Higher specification are accepted as part of technical bid	

48 Port PoE Edge / Distribution Switch

S. No.	48 Port PoE Switch Specification	Compliance (Yes/No)
1	Device should have 48 x 1G PoE+ Ports and 4 x 1/10G or better Uplink Ports in 1 RU fixed Form Factor, populated with 2 x 10G LR SFP supporting 10KM distance	
2	Device should have total support Throughput of 176 Gbps at least.	

S. No.	48 Port PoE Switch Specification	Compliance (Yes/No)
3	Device should support copper Base-T (1G & 10G) connectivity over CAT6 cable and 1G, Dual rate 1G/10G SFP+ fiber connectivity over MM and SM cable for the Uplink ports.	
4	The switch should support minimum of 30W (802.11at) on all 48 ports	
5	Device should support upto 64K MAC address and 32K IPv4, 16k IPv6 host routes simultaneously	
6	Device should support upto 16K IPv4 and 6k IPv6 routes simultaneously	
7	Device should have 1G management port, USB port and console port	
8	Device should have at least 4GB of RAM and 8GB of Flash memory	
9	Device should support 4096 VLANs, 9216 Jumbo frame	
10	Device should support MST, per-vlan, RSTP, BPDU Guard, Loop Guard	
11	Device should support upto 64 MST and 254 PVST instance	
12	Device support LLDP, LLDP-MED and LACP to bundle links and detect miscabling issues.	
13	Device Should support IEEE 802.1D, 802.1Q, 802.1w, 802.1s, 802.3x and 802.1x and Q-in-Q	
14	Device should support upto 4k IGMP groups	
15	Device should support Routing Protocols: OSPFv2 with multiple instances, OSPFv3, BGP, MP-BGP, IS-IS, and RIPv2	
16	Device Should support Graceful restart for BGP, OSPF v2	
17	Device Should support BFD	
18	Device Should support Policy Based Routing (PBR) for IPv4 and IPv6, VRRP V4 and V6, 32-way Equal Cost Multi-path Routing (ECMP), Unicast Reverse path forwarding (urpf), and Inter-VRF route leaking	
19	Should support GRE tunnel interface	
20	Device should support IGMP v2/v3, PIM-SM, Anycast RP (RFC 4610)	
21	Device must support following ipv6 standard for network to be IPv6 ready.	
22	Device should support VXLAN+EVPN overlay technology.	
23	Device should support Hitless upgrade & reloads in MLAG/Vpc setup.	
24	Switch should Provide constant PoE power even when switch is under maintenance or reload.	

S. No.	48 Port PoE Switch Specification	Compliance (Yes/No)
25	Device should have N+1 redundant Fans	
26	Device should have N + 1 redundant power supply	
27	Should support Storm control and Control Plane protection (CPP)	
28	should support ACL with I2, L3 and L4 parameters upto 2K ACLs	
29	Device should support security-group based segmentation of hosts independent of the network constructs like VLAN, VRF and NVO.	
30	Device should support IEEE 802.1x Authentication framework, MAC authentication, Dynamic VLAN assignment, named VLAN assignment.	
31	Device should support priority between 802.1x and Mac based authentication	
32	Device Should support secure Zero touch provisioning with options to provision Certificates artifacts on the device when it boots.	
33	should support real time state streaming/ telemetry for advance monitoring from day 1	
34	Should Support industry standard hierarchical CLI, SSHv2, HTTPS, SCP, SFTP, CLI task scheduler and configuration session.	
35	should support NTP	
36	should support SNMP v1/2/3 and OpenConfig model over gRPC/Netconf	
37	device should support Digital Optical Monitoring (DOM)	
38	Device should support real time data collection with sflow/netflow.	
39	Device should support multiple simultaneous mirroring sessions across all ports.	
40	should have programmability and automation support with on board python and bash	
41	should support 8 queues per port	
42	should support priority queue	
43	should support Weighted Fair Queue or Weighted round robin or equivalent	
44	should support ACL based classification for QoS	
45	Should support rate limiting function like policing and shaping	
46	All licenses should be provided with the devices for the mentioned features.	
47	All proposed switches except Industrial switches in the network should be able to run on same OS image and managed from single dashboard for simplified operations with minimal security exposure.	

S. No.	48 Port PoE Switch Specification	Compliance (Yes/No)
48	Visibility & Automation: Should be provided along with software for unified monitoring, provisioning, and telemetry solution from the same OEM. Should support telemetry with time-series database view, traffic flow analytics, PSIRT/BUG visibility, configuration compliance, endpoint tracking, POAP/ZTP, device resource utilization, auto topology view, alerts, Change workflow management, congestion monitoring, notification through email & msg, 3rd party integration. All Network switches (except Industrial switches) should be able to view and configured from a singel dashboard. SI will factor required VM's to install the software in HA cluster, if any OEM wants to supply their Appliance, they allowed to in HA Cluster. All Network switches should be managed from Single dashboard for simplified operations. All software should be onPrem, no Cloud solution is accepted.	
49	Device should be IPv6 Certified/IPv6 logo ready	
50	Device shall conform to UL 60950 or IEC 60950 or CSA 60950 or EN 60950 or EN 61000-3-3 Standards for Safety requirements of Information Technology Equipment.	
51	The Device should be EAL 3/NDPP/NDcPP certified under Common Criteria.	
52	All licences should be provided with the devices for the mentioned features. The licences should be perpetual in nature should be provided or 8 years from day-1 in case of subscription-based licencing. Hardware warranty 60 months from the Date of Installation Sign off. Confirmation on this need to be mentioned in signed MAF, any deviation will lead to rejection of Technical Bid.	
53	OEM & Bidder should not be from a country which shares a land border with India and Hardware shouldn't be Manufactured & Assembled from a country which shares a land border with India. Same should be declared in MAF.	
54	All Network Switches should from Same OEM, for better support and no compatibility issue come up at later stage	
55	All Network Switches should run on same OS for simplified operations.	
56	All Network Switches quoted Models should have support life of 8 years minimum from the Date of delivery at Site, same need to be confirmed in signed MAF.	
57	Bidder should submit fully complied solution, any deviation will result in bid rejection and Intentional wrong	

S. No.	48 Port PoE Switch Specification	Compliance (Yes/No)
	compliance claims will result in blacklisting of OEM & Bidder for next 3 years	
58	Specification mentioned are minimum required for critical network infrastructure, which is the backbone, any Bidder / OEM can quote higher specification with more advance features and with higher buffer, RAM, flash and processor cores	
59	Any deviation towards lower specification will result in rejection of the Technical Bid. Only Higher specification are accepted as part of technical bid	

8 Port PoE+ Industrial Grade Switch Specification

S. No.	8 Port PoE Ruggedized Switch Specification	Compliance (Yes/No)
1	Device should have 8 x 1G Ethernet with 802.3af/at PoE+ or higher port and 2 x 1/10G or better Uplink Ports, populated with 2 x 10G LR SFP supporting 10KM distance	
2	Device should have total Throughput of 64 Gbps.	
3	Device should support copper Base-T 1G connectivity over CAT6 cable and 1/10G SFP+ fiber connectivity over MM and SM cable for the Uplink ports.	
4	Device should support upto 32K MAC address and 8K IPv4 simultaneously	
5	Device should have USB port and console port	
6	Device should support 4096 VLANs, 9216 Jumbo frame	
7	Device should support MST, per-vlan, RSTP, BPDU Guard, Loop Guard	
8	Device support LLDP, LLDP-MED and LACP to bundle links and detect miscabling issues.	
9	Device Should support IEEE 802.1D, 802.1Q, Q-in-Q, 802.1s, 802.3x and 802.1x	
10	Device should support IGMP v2/v3	
11	Switch should Provide constant PoE power even when switch is under maintenance or reload.	
12	Switch should have a PoE input port to power itself.	
13	should support ACL with I2, L3 and L4 parameters	
14	should support limiting number of mac address on a link	
15	Device should support IEEE 802.1x Authentication framework, MAC authentication, Dynamic VLAN assignment	
16	Device Should support Zero touch provisioning.	
17	Should Support industry standard hierarchical CLI, SSHv2 and configuration session.	
18	should support SNMP v1/2/3	

S. No.	8 Port PoE Ruggedized Switch Specification	Compliance (Yes/No)
19	Device should support real time data collection with sflow/netflow.	
20	Device should support multiple simultaneous mirroring sessions across all ports and tunnelling of mirror packets to remote server	
21	should support 8 queues per port	
22	should support priority queue	
23	should support Weighted Fair Queue or Weighted round robin or equivalent	
24	should support ACL based DSCP marking	
25	Should support Explicit Congestion Notification (ECN)	
26	Should support rate limiting function like policing and shaping	
27	All licenses should be provided with the devices for the mentioned features.	
28	Device should be IPv6 Certified/IPv6 logo ready	
29	Device shall conform to UL 60950 or IEC 60950 or CSA 60950 or EN 60950 or EN 61000-3-3 Standards for Safety requirements of Information Technology Equipment.	
30	The Device should be EAL 3/NDPP/NDcPP certified under Common Criteria.	
31	All licences should be provided with the devices for the mentioned features. The licences should be perpetual in nature should be provided or 8 years from day-1 in case of subscription-based licencing. Hardware warranty 60 months from the Date of Installation Sign off. Confirmation on this need to be mentioned in signed MAF, any deviation will lead to rejection of Technical Bid.	
32	OEM & Bidder should not be from a country which shares a land border with India and Hardware should not be Manufactured & Assembled from a country which shares a land border with India. Same should be declared in MAF.	
33	All Network Switches quoted Models should have support life of 8 years minimum from the Date of delivery at Site, same need to be confirmed in signed MAF.	
34	Bidder should submit fully complied solution, any deviation will result in bid rejection and Intentional wrong compliance claims will result in blacklisting of OEM & Bidder for next 3 years	
35	Specification mentioned are minimum required for critical network infrastructure, which is the backbone, any Bidder / OEM can quote higher specification with more advance features and with higher buffer, RAM, flash and processor cores	

S. No.	8 Port PoE Ruggedized Switch Specification	Compliance (Yes/No)
36	Any deviation towards lower specification will result in rejection of the Technical Bid. Only Higher specification are accepted as part of technical bid	

1.7.2 Technical Specifications of Wi-Fi Equipments**Technical Specification of Wi-Fi Controller / Manager**

S No	Technical Specifications of Wi-Fi Controller / Manager	Compliance (Yes/No)
A	Solution Architecture	
1	The solution should provide Wi-Fi services including, but not limited to, Wi-Fi Access, WIDS, WIPS, Network assurance and Location tracking. From Day 1, all relevant licenses should be included for the same.	
2	The proposed Wi-Fi management server should be Cloud Based (Should be in MEITY approved Cloud provider). In Future in case if department needs to move to onPrem from Cloud same lic can be used and all features asked in specification need to be supported. (No order for OnPrem lic, migration will be provided by department). Confirmation same need to be submitted as part of signed MAF.	
3	The solution should provide group PSK on a single SSID without requiring any external plugin, or device	
4	The solution should facilitate Control and Provisioning of Wireless Access Point devices and ensure data encryption between access point devices and management servers across remote WAN/LAN links	
5	The solution should support tunnelling traffic to a DMZ zone using layer - 2 tunnelling protocol directly from AP without the need of a controller, or gateways. if it requires controllers, they should be part of the overall solution BoQ while bidding.	
B	Management server	
1	The WLAN Manager should provide centralized Wi-Fi, Network assurance, WIPS and client location tracking management system from single pane of glass	
2	The management server should have role-based admin rights to manage the controller.	
3	The management server should support open APIs for integration with 3rd party configuration management, inventory management, performance management, process automation, reporting, WLAN monitoring tools etc.	

S No	Technical Specifications of Wi-Fi Controller / Manager	Compliance (Yes/No)
4	The Solution should allow blocking traffic based on IP address, port, URI, hostname, application etc. and QoS (for example: bandwidth restriction for the SSID, QoS tagging of special traffic like Voice) at the edge (AP).	
5	The Wi-Fi solution should support sending alerts to on-prem 3rd party SNMP servers via SNMP v1, v2c, v3	
6	The solution should maintain management server user action logs which should include all activities performed by the user like login, any configuration changes made on the system, device deletion, device authorization, log out etc.	
7	The solution should enable wireless client association logs which should record client MAC address, AP connected to, data transfer, data rate, session duration, content - domain (http, https, IP address)	
8	The solution should allow VLAN segmentation at the Access point even in case of tunnelling back traffic to a central location.	
9	Time Schedules - the solution should allow configuration of time schedules when WLAN is / isn't available (For example: SSIDs can be active from 9 am to 5 pm and then automatically disabled)	
10	The solution should send event notifications based on location and alarm type	
11	The solution should allow location based automatic schedules for report generation and distribution of reports to specific users via email	
12	The Solution should support RRM features like Auto transmit power control, Client load balancing, Band steering, Minimum association RSSI, Sticky client remediation.	
C	Management and Monitoring	
1	The solution should have all locations consolidated dashboard and location-specific dashboard as well.	
2	The WLAN management plane should have visual hierarchal location tree, where the nodes of location tree inherit settings and configuration from the global level into subsequent levels in the hierarchy.	
3	The solution should provide hierarchical alerts wherein sub-events are correlated under parent incident alert thereby enabling event correlation.	
4	The management server should have AP Group based policy management and administration.	

S No	Technical Specifications of Wi-Fi Controller / Manager	Compliance (Yes/No)
5	The solution should support automatic DHCP fingerprinting to allow or deny a client based on client OS from associating with an access point (AP), restrict clients in a specific VLAN, bandwidth control, apply firewall rules and apply other network policies.	
6	The management server should enable application visibility and control. It should display list of applications with their data usage for a specific SSID as well as per client.	
7	The system should support remote packet captures on AP radio and Ethernet ports without disrupting the client connectivity of any of the APs.	
8	The solution should support RF spectrum analysis on both 2.4GHz & 5GHz band to visualize spectrum analysis as a real-time spectrogram view, RF interference, spectrum density and duty cycle of other RF signals.	
D	Network Assurance	
1	The solution should support automated root cause analysis to highlight probable network causes for client impacting wireless issues, Wi-Fi issues such as low RSSI, low data rate, Authentication related issue on per client basis.	
2	The solution should highlight client connection failures during association, authentication, and network entry. It should also identify the cause of failure.	
3	The solution should highlight the reason of client connection failures related to association, authentication and network onboarding of users and specify the exact reason of failure such as association limit, capability mismatch, Radius authentication failure, EAPOL failure, fast roaming failure, Radius server not responding, web auth failure, DHCP failure, DNS failure, WPA2 4 way handshake failure, incorrect PSK entered by user etc	
4	The solution should support client emulation/synthetic client to perform remote testing. To be achieved by connecting to other nearby Access Point, all required hardware should be part of the BoQ	
5	The Solution should highlight User's application experience/performance for well-known VoIP based application such as Ms Teams, Skype, Zoom, Hangout, Webex etc.	
6	The solution should support monitoring the performance of custom web-based enterprise applications which are TCP based without code change.	

S No	Technical Specifications of Wi-Fi Controller / Manager	Compliance (Yes/No)
7	The solution should provide recommendations of possible actions that can be taken for remediations of client's performance impacting issues.	
8	The solution should be able to baseline important metrics related to client connectivity and performance such as Retry rate, data rate, latency, and client authentication to define normal for each network/ site and highlight anomalous events that deviate from the regular baseline.	
E	Upgrades and Updates	
1	The system should support manual and scheduled automatic system backup.	
2	The management server and AP can be on different software versions.	
3	The management server should be able to rollback software version of all APs and a group of APs as per requirement to previous version without rolling back management server version.	
4	The AP Upgrade to management server version should be flexible and can be scheduled on per AP basis, AP group basis and site basis as required.	
5	The Solution should support hitless upgrade for APs all required hardware should be part of the BoQ	
6	For management and monitoring operations, the management server should provide a web interface, and APIs.	
F	WIPS	
1	The solution should auto-classify APs precisely in different categories as managed / authorized (i.e., managed device connected to the networks), external (i.e., un-managed APs not connected to the networks, e.g., neighbours), and rogue APs (un-managed AP connected to the networks)	
2	The solution should have the capability of auto classifying Wi-Fi clients as authorized (managed clients connecting to the network), guest, rogue (un-managed client attempting connection to the network) or external (unmanaged not connecting to the network e.g., neighbour), in addition to manual classification	
3	The solution should be able to detect and automatically prevent all types of Rogues (unauthorized APs connected to the wired network infrastructure) APs, such as: a) APs such as Bridge and NAT b) MAC-adjacent Open/Encrypted Wi-Fi routers	

S No	Technical Specifications of Wi-Fi Controller / Manager	Compliance (Yes/No)
	c) Non-MAC-adjacent OPEN Wi-Fi routers d) Non-MAC adjacent APs having MAC ACLs	
4	The solution should detect mis-configured authorized APs and automatically prevent them.	
5	The solution should detect and prevent outside client trying to connect to the Authorized WLAN	
6	The solution should detect Honey Pot attacks including its advanced variants such as Multiport attack. It should be able to prevent the authorized client from connecting to a honeypot AP.	
7	The WIPS solution should NOT affect the operation of an external (i.e., neighbours) or a managed access point while preventing a rogue AP on the same channel.	
8	The solution should be able to detect wireless Denial of Service (DoS) attacks	
9	The solution should provide forensic data aggregated for major threat vectors like Rogue AP, Honeypot AP, Mis-Configured AP, DoS, Unauthorized Association, Ad Hoc Networks, Bridging/ICS Client, Mis-Association.	
10	WIPS shall be able to detect and prevent on DFS channels as well.	
11	AP should support detection and prevention of 11ax clients in case of WIPS policy violation.	
12	The solution should provide location tracking of a DoS attacker, all other malicious devices such as Rogues/Honeypots etc	
13	Solution should be able to do wired prevention of WIPS if wireless prevention is not available for some reason and it should be able to do so without any proprietary integration.	
G	Overall	
1	Solution should support all features mentioned above from day 1, and all relevant licenses and hardware for the features mentioned should be included on the BoQ while bidding	

Technical Specification of Wi-Fi Access Points

Sl. No	Technical Specifications of Wi-Fi Access Point Indoor Applications	Compliance (Yes/No)
1	Wi-Fi AP devices should be 802.11ax WIFI 6 certified and the solution should support the following protocols: IEEE 802.11ax (WIFI 6), 802.11a/b/g, IEEE 802.11n, IEEE 802.11ac (WAVE 2), 802.11i, 802.11 r/k/v.	
2	AP Should support following Wi-Fi 6 Features from day 1: 1. UL & DL MU-MIMO 2. UL & DL OFDMA 3. Target Wake Time 4. BSS Coloring 5. STBC	
3	The AP should support the following authentication methods: WPA/WPA2-AES, PSK, authentication and AES encryption and 802.1x/EAP and unauthenticated (open) mode, Radius CoA.	
4	Should have at least 1 x 100/1000/2500/5000 Mbps, 1 x 1000 Mbps interface RJ45 interface.	
5	AP should support link aggregation (LACP) between the Ethernet ports.	
6	Proposed AP should support 802.3at to power up the AP with full functionality, should have capability to power up the AP and operate with reduced functionality on 802.3af power,	
7	Proposed AP should support minimum 0.6 Gbps on 2.4 GHz radio and 2.4 Gbps on 5GHz radio	
8	The AP should Support 4x4:4 on 5GHz and 2x2:2 on 2.4GHz on another radio.	
9	The AP should support tunnelling user traffic to a centralized DMZ zone using open standard based layer-2 tunnelling protocol without controller or management server coming into data path	
10	29dBm on 5GHz radio and 26dBm on 2.4GHz radio (max)	
11	AP should support SSH for local or remote access to device through CLI.	
12	AP should support wall mount & ceiling mount options with included accessories from day 1	
13	AP should be Wi-Fi Alliance certified. APs should be compliant with all applicable national regulations. WPC certificates need to Provide before deployment	
14	AP should support WPA3 Enterprise with 192-bit encryption CNSA Suites	
15	The AP should Support WPA3-SAE, WPA3-Enterprise, WPA3 Transition Mode, OWE and OWE transition Mode	

Sl. No	Technical Specifications of Wi-Fi Access Point Indoor Applications	Compliance (Yes/No)
16	Wi-Fi APs and the system should have ability to set SSIDs as either in bridge mode or NAT mode or tunnelled mode. AP should support all three modes.	
17	Wi-Fi APs and the system should have support for 802.1Q VLANs.	
18	AP should have capability to run 8 SSIDs per radio, and ability to map each SSID with a different VLAN.	
19	APs should support Hotspot 2.0 (802.11u).	
20	AP should support Three-radio configuration with 2 radios for Wi-Fi Access (2.4GHz and 5Ghz radio) and 3rd Dual band radio for functions like RRM, scanning, WIDS, WIPS and client emulation.	
21	The third scanning radio on AP should be minimum 2x2 dual band.	
22	AP should provide dedicated WIPS 24x7 without impairing the user experience on Wi-Fi	
23	AP should support on-demand client emulation for network assurance that can be scheduled without disturbing the connected clients using the third dual band radio.	
24	AP should support automatic, and on-demand wired and wireless packet capture using the third radio	
25	The Access Point should have BLE radio	
26	AP should be remotely upgradeable from the controller, so that new features and upgrades can be added.	
27	AP should be upgraded to a given version irrespective of management server version	
28	AP should support hitless upgrades from day 1.	
29	All Wi-Fi, WIDS, WIPS services should remain functional even if the link between AP and its on-prem management server goes down.	
30	All Wi-Fi functions including RRM (Radio resource management), Roaming, tunnelling traffic back to central location, TPC, Dynamic Channel Selection etc should remain functional even if the link between AP and its on-prem management server goes down.	
31	AP should be able to onboard new clients and do radius authentications for WLANs which tunnel traffic to a central location even if the link to on-prem management server goes down.	
32	Wi-Fi AP should support dual stack for IPV4 and IPV6.	
33	AP should support non-proprietary open standard based IPsec tunnelling to securely transport user traffic to remote locations.	

Sl. No	Technical Specifications of Wi-Fi Access Point Indoor Applications	Compliance (Yes/No)
34	The AP should be capable of receiving IP address via DHCP for IPv4/IPv6 and SLAAC for IPv6.	
35	The AP should support real-time data transfer for third party analytics integration	
36	The AP should support monitoring of any wired user VLAN and not just AP Management VLAN for extended rogue AP detection.	
37	The Access points should directly support management via OpenConfig, without requiring controller	
38	AP should support continuous scanning of all 2.4 GHz and 5 GHz channels through dedicated hardware radio to assist in RF optimization and client handling without impairing the user experience.	
39	AP should support 20/40/80/80+80/160 MHz channel width in 5GHz band.	
40	AP should support 20/40 MHz channel width in 2.4GHz band.	
41	Proposed AP should support cellular interference mitigation (LTE, 3G Small cell and Femto cell)	
42	Proposed AP should have antenna gain of minimum 3 dBi for both 2.4 GHz and 5 GHz bands.	
43	AP should support DFS	
44	Proposed Access point should support Mesh technology	
45	The AP should support application visibility, traffic shaping, QoS per SSID.	
46	AP should support VxLAN over IPsec or equivalent for encryption of data traffic from remote sites	
47	AP should be able to tunnel traffic to remote location without the need of management server or controller, using open standard non-proprietary protocols like VxLAN	
48	AP should support BLE scanning	
49	AP should provide detection of threats such as, but not limited to: - Rogues APs are the unauthorized, unmanaged APs which are connected to organization's wired infrastructure, posing threat to leak out the sensitive data from the AP or act as an entry point into the network for hackers to do malicious activities - Neighbouring/External APs are the unmanaged, unauthorized APs which are not connected to organization's wired infrastructure, but pose a threat to authorized clients which might connect to such APs accidentally or willingly and could get malicious software such as RATs planted on themselves, making them	

Sl. No	Technical Specifications of Wi-Fi Access Point Indoor Applications	Compliance (Yes/No)
	accessible when they are on authorized network. - Honeypot APs are the unauthorized APs which announce the same BSSID as the authorized APs, these pose a threat as clients might connect to these unknowingly and their passwords could get leaked in this process. - AP Impersonation - where an unauthorized AP imitates the authorized AP and poses a threat of doing a MiTM attack on the clients, thereby stealing sensitive information from clients. The AP should be able to differentiate between threats and authorized access points with precision.	
50	AP should support mitigation from threats such as Rogue, Honeypot, Neighbour, AP Impersonation as mentioned in the above point using wired and wireless prevention techniques	
51	AP should support detection of known/authorized APs broadcasting BSSID which are not complying with the organization's security policy, for instance if WPA-PSK based SSIDs are disallowed in an organization, AP should be able to detect SSIDs which authorized APs might be broadcasting with WPA-PSK as the security mechanism and should prevent clients from connecting to it	
52	Various management as well as control frames which are sent in a non-encrypted manner (as part of the Wi-Fi standard) such as Disassociation/Association frames, RTS/CTS can be exploited, and an attacker can imitate to become a client or an AP and launch a flood of these frames, thereby disrupting the Wi-Fi service. Therefore, AP should be able to detect wireless Denial of Service (DoS) attacks such as Disassociation flood, Disassociation broadcast, RTS/CTS flood, EAPOL log off, Association flood etc	
53	Despite having prevention methods to protect against threats of Rogue, Honeypot APs by preventing clients from connecting to these APs, these APs continue to operate, and one must physically stop them from transmitting. Hence, AP should support location tracking of Rogue APs, Honeypot APs, DoS attackers etc on floor maps without any external application or server.	

Sl. No	Technical Specifications of Wi-Fi Access Point Indoor Applications	Compliance (Yes/No)
54	Threats can be present on any Wi-Fi channel including DFS channels, for govt. entities, armed forces it is crucial that AP should be able to do detection as well as prevention from threats on all channels especially DFS channels as there might be a radar already running on those channels and the unauthorized APs can disrupt the working of the radars as well.	
55	AP should be able to do wired prevention of WIPS, without any proprietary integration with the wired switch, therefore it should work on switches from all OEMs	
56	RoHS complaint and UL 2043	
57	APs should be compliant with all applicable national regulations.	
58	Proposed AP / Solution should support Layer3, Layer4 and Application firewall.	
59	Proposed AP should support Rx sensitivity of -98dbm	
60	The AP should support humidity range 0-95%	
61	AP should support on-prem management server, this feature may require in future without changing the software of the AP, same can be managed from onPrem VM's with same license, without any Cost Hit to Department. Confirmation for the same need to be mentioned in Signed MAF.	
62	AP should support all features mentioned above from day 1, and all relevant licenses for the features mentioned should be included. Hardware & Software Support 60 months.	
63	Hardware replacement warranty and TAC support should be directly from the OEM. OEM email-id and India Contact support no. to be provided.	
64	OEM & Bidder should not be from a country which shares a land border with India and Hardware should not be Manufactured & Assembled from a country which shares a land border with India. Same should be declared in MAF.	
68	All Network Switches & Wi-Fi quoted Models should have support life of 10 years minimum from the Date of delivery at Site, same need to be confirmed in signed MAF.	

- **Wi-Fi Access Points Configuration:**

- **Wi-fi Access points 2x2:**

- ✓ The switch should be a tri-radio 2x2:2SS 802.11ax Wireless Access Point with maximum data rates of 1,200 Mbps in the 5GHz band and 575 Mbps in the 2.4GHz band.
- ✓ It should have an integrated 3rd radio that functions as a network, location & security sensor, and a spectrum monitor.

- ✓ It should have 1 x 1GBaseT RJ-45 with 802.3af PoE In, 1 x 1GBase-T RJ-45 with PoE Out and additional 2 x 1GBase-T RJ-45 ports and should support Two spatial stream Multiuser (MU) MIMO for up to 1,200 Mbps wireless data rate to up to four MU-MIMO-capable client devices simultaneously. The AP shall be having minimum 4 no of ports with a configuration of 1 incomer and 3 outgoings from which LAN points shall be feeded.
- ✓ The switch should have a dedicated internal Omni-directional BLE Antenna
- ✓ Mounts: To be mounted on Wall plate. Hence, appropriate OEM mounts to be included
- ✓ The Access Point Should Support Advanced security features including Rogue Detection, WIPS, Neighbour AP and Honeypot AP Detection. Any license required for the same shall be provided from the start.
- ✓ It should support 802.11ax (Wi-Fi 6), including support for OFDMA, 1024-QAM, MU-MIMO, Target Wake Time (TWT), and Spatial Frequency Reuse (BSS Coloring).
- ✓ It should support Proactive Analytics and Correlation technologies that leverage machine learning to analyse user experience, correlate problems and automatically detect the root cause of problems
- ✓ It should support Transmit Beamforming & Maximal Ratio Combining with modern WIFI authentication protocols such as, Pre-shared Key (PSK), Captive Portal, Extensible Authentication Protocol (EAP), 802.11i
- ✓ Essential support for Wireless Security features of WPA2 or later with AES Encryption technology
- ✓ Should support WPA3 Enterprise as well as Opportunistic Wireless Encryption (OWE) that adds encryption to open networks.
- ✓ Should support 802.1x for Client Authentication and Rad Sec to allow RADIUS servers to transfer data over TCP and TLS for increased security.
- ✓ Should have Guest Access functions from day 1 with fully customizable Captive Portal to include, Guest SSID, Guest VLAN, Captive Portal, Time limits before re-authentication and Access Control Lists (ACL) preventing guest VLAN from accessing internal LAN.
- ✓ The Access Point Should support 802.11k, 802.11r, and 802.11v for client roaming.
- ✓ Shall support a WLAN Rate limit option to provide per client rate limit and application rate limit that allows to limit total bandwidth available for specific applications
- ✓ Monitoring and Reporting: Using various graphs, the offered WIFI solution shall have the ability to monitor the system on a client, AP, application, and port level makes managing the network
- ✓ Solution should have an Analytics and Correlation Engine to understand the actual end user experience on the network by measuring key parameters such as Time to Connect, Throughput, Coverage, Capacity, Roaming, Successful Connects and AP Health in real time
- ✓ Should support Client Roaming Visualization in UI and should provide a graphical representation of client roams with granular view of all roam events, including short interval roams.

- ✓ Should support Zero Touch Provisioning and have ability to do Auto provisioning for AP assignment to sites and getting the relevant configuration. Should support Site Assignment, Device Profile Assignment & AP Name Generation
 - ✓ Should support Radio Resource Management (RRM) to allow viewing channel and transmit power across all APs on the network.
 - ✓ Radio Resource Management should support auto cancellation to automatically disable 2.4 GHz radios to ensure the most efficient use of available spectrum.
 - ✓ Should provide Current Radio Values per AP and Channel Occupancy with historical data
 - ✓ Should support Backwards compatibility with 802.11a/b/g/n/ac devices and also have option to disable legacy wireless standards such as 802.11b/g.
- **Wi-fi Access points 4x4:**
- ✓ The switch should be a 6 stream 802.11ax access point supporting 4x4:4SS in the 5GHz band, delivering a maximum data rate of 2,400 Mbps and 2x2:2SS in the 2.4 GHz band, delivering a maximum data rate of 575 Mbps
 - ✓ The switch should have an integrated 3rd radio that functions as a network, location & security sensor, and a spectrum monitor.
 - ✓ The switch should have 1 x 2.5GBaseT RJ-45 with 802.3at PoE and additional 1 x 1GBase-T RJ-45 ports with a support of Four spatial stream Multiuser (MU) MIMO for up to 2,400 Mbps wireless data rate to up to four MU-MIMO capable client devices simultaneously.
 - ✓ It should have a dedicated internal Omni-directional BLE Antenna
 - ✓ Mounts: To be mounted on Ceiling. Hence, appropriate OEM mounts to be included and shall be fixed in GI boxes at required locations
 - ✓ The Access Point Should Support Advanced security features including Rogue Detection, WIPS, Neighbour AP and Honeypot AP Detection. Any license required for the same shall be provided from Day 1.
 - ✓ It should support 802.11ax (Wi-Fi 6), including support for OFDMA, 1024-QAM, MU-MIMO, Target Wake Time (TWT), and Spatial Frequency Reuse (BSS Coloring).
 - ✓ It should support Proactive Analytics and Correlation technologies that leverage machine learning to analyse user experience, correlate problems and automatically detect the root cause of problems
 - ✓ It should support Transmit Beamforming & Maximal Ratio Combining
 - ✓ Support for modern WIFI authentication protocols such as, Pre-shared Key (PSK), Captive Portal, Extensible Authentication Protocol (EAP), 802.11i
 - ✓ Essential support for Wireless Security features of WPA2 or later with AES Encryption technology
 - ✓ It should support WPA3 Enterprise as well as Opportunistic Wireless Encryption (OWE) that adds encryption to open networks.
 - ✓ It should support 802.1x for Client Authentication and Rad Sec to allow RADIUS servers to transfer data over TCP and TLS for increased security.
 - ✓ It should have Guest Access functions from day 1 with fully customizable

Captive Portal to include, Guest SSID, Guest VLAN, Captive Portal, Time limits before re-authentication and Access Control Lists (ACL) preventing guest VLAN from accessing internal LAN.

- ✓ The Access Point Should support 802.11k, 802.11r, and 802.11v for client roaming.
 - ✓ Shall support a WLAN Rate limit option to provide per client rate limit and application rate limit that allows to limit total bandwidth available for specific applications.
 - ✓ Monitoring and Reporting: Using various graphs, the offered WIFI solution shall have the ability to monitor the system on a client, AP, application, and port level makes managing the network
 - ✓ Solution should have an Analytics and Correlation Engine to understand the actual end user experience on the network by measuring key parameters such as Time to Connect, Throughput, Coverage, Capacity,
 - ✓ Roaming, Successful Connects and AP Health in real time
 - ✓ Should support Client Roaming Visualization in UI and should provide a graphical representation of client roams with granular view of all roam events, including short interval roams.
 - ✓ Should support Zero Touch Provisioning and have ability to do Auto provisioning for AP assignment to sites and getting the relevant configuration. Should support Site Assignment, Device Profile Assignment & AP Name Generation
 - ✓ Should support Radio Resource Management (RRM) to allow viewing channel and transmit power across all APs on the network.
 - ✓ Radio Resource Management should support auto cancellation to automatically disable 2.4 GHz radios to ensure the most efficient use of available spectrum.
 - ✓ It should provide Current Radio Values per AP and Channel Occupancy with historical data
- **Convertors and Adaptors:**
- ✓ The requirement of adaptors with QSFP+ 40GBase SM Optics, up to 2km Transmission
 - ✓ Supplying, installation, testing and commissioning of Optical Transceiver, multi-mode SFP+ (10G) Module minimum 550m inside the LIU panel before distribution switches.

1.7.3 Technical Specifications of Firewall / Unified threat management (UTM)

- The minimum requirement of Firewalls with the following's major features and minimum essential specifications: -
 - ✓ Major supported features:
 - ❖ Anti-Virus
 - ❖ Intrusion Prevention System (IPS)
 - ❖ Web filtering
 - ❖ E-mail filtering, including protection against spam and grayware
 - ❖ Data Leak Prevention (DLP)
 - ❖ Application Control
 - ❖ Traffic inspection
 - ❖ Content inspection and filtering
 - ❖ Security Profiles components

- ❖ Security Profiles/lists/sensors
- ❖ Logging and reporting

✓ Minimum Specifications for Firewall

Description	Technical Compliance Parameter
Type	NGFW
Form Factor (RU)	1
Features	Layer 3 - Layer 4, NAT, VPN, Application Visibility and Control (AVC), User Identity, Next Generation Intrusion Prevention System (IPS), Zero Day Protection / Advance Malware protection, Web Security Essentials / URL Filtering
Traffic handled	TCP, UDP, HTTP/TCP, TCP/UDP
Hardware Architecture & Performance	1. The appliance hardware should be a multicore CPU architecture with a hardened 64-bit operating system with min. 32 GB memory. It should also have dedicated co-processor with min 8 GB RAM for hardware acceleration for network processing. 2. The appliance-based security platform should be capable of providing Next Gen Web Protection, Application Control, IPS, DOS, SSL/TLS Inspection & zero-day protection in a single appliance. 3. The quoted should have 8000 Mbps SSL/TLS inspection throughput or 4. The firewall Security Heartbeat policies can able to limit access to network resources or completely isolate compromised systems until they are cleaned. Firewall should be IPv6, SD-WAN from day 1
NGFW Throughput (Measured with Firewall, IPS, Application Control enabled)	22000 Mbps or higher
Threat Protection throughput (Measured with Firewall, IPS, Application Control, and Malware Prevention enabled)	4500 Mbps or Higher
Concurrent Session / Concurrent Connection	350 K or higher

Description	Technical Compliance Parameter
General Management	a. The firewall should support innovative technology for application acceleration. B. The quoted solution should be ready for extended Detection & Response (XDR) with endpoint, Server protection product from same OEM. Should have single management console for Firewall, Endpoint, Server, email security and cloud security product. c. The firewall should include exploit prevention and Crypto guard Protection technology from endpoint security d. The firewall should have optional data centre selection and flexible user and group policy options on file type, exclusions, and actions on analysis e. The firewall should have fully transparent proxy for antimalware and web-filtering, Enhanced Advanced Threat Protection f. It Single client support for IPsec & SSL remote VPN with unlimited free mobile authenticator for android & IOS g. It should have minimum 1000 IPsec & 1000 SSL client license from day 1. The firewall should support TLS 1.3 inspection of encrypted traffic.
IPS Features	a. The firewall should have advance Threat Protection (detect and block network traffic attempting to contact command and control servers using multi-layered DNS, AFC, and firewall). The firewall should security heartbeat instantly identifies compromised endpoints including the host, user, process, incident count, and time of compromise. b. The firewall should have advanced web malware protection with JavaScript emulation, Live Protection real-time in-the-cloud lookups for the latest threat intelligence c. The firewall should have URL Filter database with millions of sites across 92 categories backed by OEM Labs
Type of Interface	GE Copper, SFP, SFP+
Number of 1 GbE Copper RJ 45 interface from day 1	8 or more

Description	Technical Compliance Parameter
Number of 1/10G SFP+ interface from day 1 (Populated with 3 no. 1 GbE Single Mode LC Type Transceivers)	4 or more
Number of GbE Small Form-Factor Pluggable (SFP) interface Slot / Module supported for future	6 or more
Number of 1/10 GbE SFP+ interface Slot/Module supported for future	2 or more
Number of IPsec VPN Peers supported (Site to Site)	4500 or higher
Number of IPsec VPN Peers supported (Client to Site)	4500 or higher
Number of SSL VPN Peers supported (Client to Site)	2000 or higher
Type of Storage Disk	SSD
Storage Capacity (TB)	1 or higher
Power Supplies from day 1	2 or more
Type of Processor	x86
High Availability Support	Yes
Interface Expansion slots supported	2 or more
Firewall Policies - License	Yes
Details of the Firewall Policies for the Firewall provided with the License	Web Security Essentials / URL Filtering, IPS License, Application Visibility License, APT (Advance Persistent Threat) License, Anti Malware Protection, C& C attacks, Geo IP Protection, Zero Day Threat Protection) and Web & Application Firewall (WAF) from day 1
NGIPS Signature supported	25000 or higher
Security Intelligence	IP, URL, Domain

Description	Technical Compliance Parameter
Certification	The quoted firewall should have ICSA/EAL4+ certified. /NSS/NDPP Lab certified or equivalent certificate with minimum 93% security effectiveness as per last report. Certificates should be enclosed. The quoted firewall should have purpose-built, streamlined user interface and rule management for large rule sets with grouping with at-a-glance rule feature and enforcement indicators. Proposed NGFW should be in Gartner Magic Quadrant in Network Firewall as per the latest report.
Installation and commissioning	The quoted firewall should be capable to restore the existing firewall policies and setting without using third party software. The bidder must configure the firewall as per the scope of work.
Documentation	All supporting documents such as datasheet, spec sheet, admin guide etc for the asked features must be enclosed.
On site OEM Warranty and License	a. The firewall should be quoted with 36 months License. b. All supporting documents such as datasheet, spec sheet, admin guide, certificates etc must be enclosed. All documents should be readily available online. Bidder must share the online links for all the submitted documents. c. License should include Web / URL / Content Filtering, Application Control and Visibility, IPS, Antimalware, WAF, Zero-Day Protection & 24 X 7 hardware & warranty support from the OEM.

✓ **Additional Notes for Contractor / Bidder:**

- The Contractor / OEM must furnish the guidelines by OEM for installation / configuration planning of hardware and software before the start of the project.
- Complete installation and integration and customization will be taken place at TIDEL, Madurai, no remote access will be provided for the same. The Bidder must migrate all the existing Firewall policies, settings etc. to the proposed Firewalls.
- No downtime shall be provided during the migration. Downtime shall be provided in later stage of physical migration. The Bidder shall also customize, add, edit rules/policies as per required by TIDEL.
- The solution shall be centralized controller-based deployment architecture that is required for granular control, simplified management, monitoring and for one click configuration. The Firewall shall be configured in Active-Active High Availability (HA) for Load Balancing and Failover.

- The solution shall be based on VLAN authentication, DHCP, MAC-IP based tight integration method by enabling all security as per guidelines. ‘
- To increase backbone bandwidth, Link Aggregation must be configured in Firewalls in LAN, DMZ and WAN Side.
- At the time of installation of the systems/sub-systems, if it is found that some additional HW/SW/Licenses or additional items are required to complete the configuration, which was not included in the Bidder's original list of deliverables/BOM, then the vendor is required to supply such items to ensure the completeness at no extra cost to TIDEL. The proposed solution shall be inclusive of installation/services/Accessories cost.
- Bidder must include installation, commissioning and integration, or any technical support cost for the period of 3 years. The bidder has to provide undertaking for the complete troubleshooting, day to day support, any hardware and software upgradation and technical support for the period 3 years. The OEM certified Engineer of the Bidder has to visit TIDEL for preventive maintenance on quarterly basis for the period of 3 years.
- The OEM must provide an undertaking that the quoted product shall not be end of life for minimum 5 years from the date of submission of quote.

1.7.4 Enterprise Network Management System

- To ensure that ICT systems are delivered at the performance level envisaged, it is important that an effective monitoring and management system be put in place. It is thus proposed that a proven Enterprise Management System (EMS) is proposed by the bidder for efficient management of the system, reporting, SLA monitoring and resolution of issues. Various key components of the EMS to be implemented as part of this engagement are
 - ✓ Network Monitoring System
 - ✓ Server Monitoring System
 - ✓ Helpdesk System
- The solution should provide a unified web-based console which allows role-based access to the users.
 - ✓ **Network Management System**
 - ❖ Solution should provide fault & performance management of the server-side infrastructure and should monitor IP\SNMP enabled devices like Routers, Switches, PA System, Emergency Call Boxes, Sensors, etc. Proposed Network Management shall also help monitor key KPI metrics like availability, in order to measure SLA's. Following are key functionalities that are required which will assist administrators to monitor network faults & performance degradations in order to reduce downtimes, increase availability and take proactive actions to remediate & restore network services.
 - ❖ Solutions should comply with The International Organization for Standardization (ISO) network management model defines five functional areas of network management

- ❖ The ISO network management model's five functional areas are listed below.
 - Fault Management—Detect, isolate, notify, and correct faults encountered in the network.
 - Configuration Management—Configuration aspects of network devices such as configuration file management, inventory management, and software management.
 - Performance Management—Monitor and measure various aspects of performance so that overall performance can be maintained at an acceptable level.
 - Security Management—Provide access to network devices and corporate resources to authorized individuals.
 - Accounting Management—Usage information of network resources
- ❖ The solution should have also capable of following features
 - The proposed solution must automatically discover manageable elements connected to the infrastructure and map the connectivity between them. Solution should provide centralized monitoring console displaying network topology map.
 - Proposed solution should provide customizable reporting interface to create custom reports for collected data.
 - The system must use advanced root-cause analysis techniques and policy-based condition correlation technology for comprehensive analysis of infrastructure faults.
 - The system should be able to clearly identify configuration changes and administrators should receive an alert in such cases.
- ✓ **Server Performance Monitoring System**
 - ❖ The proposed tool should integrate with network performance management system and support operating system monitoring for various platforms supplied as part of this Project.
 - ❖ The proposed tool must provide information about availability and performance for target server nodes.
 - ❖ The proposed tool should be able to monitor various operating system parameters such as processors, memory, files, processes, file systems, etc. where applicable.
- ✓ **Centralized Helpdesk System**
 - ❖ Helpdesk system should provide incident management, problem management templates along with helpdesk SLA system for tracking SLA's pertaining to incident resolution time for priority / non-priority incidents.
 - ❖ System should also automatically create tickets based on alarm type
 - ❖ The proposed helpdesk solution must provide flexibility of logging, viewing, updating, and closing incident via web interface for issues related to the project.
 - ❖ The solutions should be capable of more proactive and preventing future incidents through visibility and analysis of experience
 - ❖ The solutions should be completely complied with latest ITIL standard framework

1.7.5 Technical Specification of IP-PBX System

- **Architecture**

- The system should be based on Distributed IP Architecture with redundancy of CPU. The connectivity from Server to Gateway shall be on IP. The offered IP PBX must be approved by TEC under GR vide No: TEC/GR/SW/PBX-005/01/SEP-16 for IP PBX with Media Gateway. TEC Certificate based on IR or ER for conventional / Hybrid EPABX shall not be acceptable.
- Standalone FXO and FXS and PRI Gateways shall not be accepted
- The proposed IP based EPABX system shall be expandable to Capacity up to 1500 subscribers (inclusive of all types of Subscribers).
- The IPPBX system should be able to provide a single unified platform connecting signal units for catering to current requirement of ports. This should be possible with a single system using same processing unit and NOT through networking of multiple IP EPABX systems and Cascading/clustering of Servers
- The IP based EPABX system should have non- blocking architecture at all levels like System processing, Switching fabric & other resources like DTMF receivers, R2 Receivers.
- The system shall have universal slots shall support the digital ports with simultaneous voice & data, and analog ports with DTMF / CLI Signaling, standalone DTMF receiver ports, IP ports, E1 ports, CO ports, GSM Ports/support for GSM, ISDN PRI ports, Alarm ports, paging Port and In Skin Fiber card

- **Redundancy and Self Survivability**

- System redundancy: The system shall be provided with 100% duplicated in 1+1 Hot Standby mode. The CPU shall be provided in hot-standby mode in such a manner that if one CPU fails the second CPU shall be able to take the complete load of calls automatically (without any manual intervention) without dropping any existing calls (IP, TDM & PRI). System should be providing Geographical redundancy using self-survivable Gateway architecture
- During an event of CPU Failure Media Gateways/IP PBX must work on redundancy mode and without any disconnection of ongoing calls and must provide same class of service to all the extensions (Analog, IP and Digital) and with same numbering scheme without any manual changes.

- **Security**

- The entire solution should have inbuilt firewall protection for security. The entire stack shall have inbuilt FW application with AES 256-bit encryption employing SRTP/TLS protocols.
- The offered PBX should be supplied with Firewall solution either in skin or external for security of IP Phones.
- Account access authentication/restriction using external RADIUS resources.
- The Operating System used by the call server must not use or natively support network resource sharing services such as NFS, samba, LPR etc.

- The System must support Syslog services for both internal and external command and configuration control accounting with a minimum of 5-day history.
- The offered system should be supplied with Necessary license to view the log history of the admin users with commands, changes made in the programming.
- Usage of MD5 algorithm (or stronger) for password encryption
- **IP PBX Application Features**
 - A web interface application should be available to selected or all Users.
 - This web interface should be accessed from all internet browsers (IE, Chrome etc.) on PC, tablet or smart phones should be available.
 - The IP- EPABX system shall support voice mail, email integration and fax messaging in an integrated multimedia messaging and Collaboration system, CTI Presence, and Instant Messaging. All these features should be available from same IP- EPABX. Call Management system and Media gateway shall be from same OEM.
 - System should be integrated with Open LDAP and Active directory systems for services like phonebook.
 - System shall support T.38 protocol to send fax over IP network.
 - System should have default feature of integration with MS Outlook with click to dial, presence and IM Features.
- **Web Page**
 - It should be possible to define more than one number to a user.
 - User should be able to see these numbers from his/her web page and edit settings of these numbers by switching between them
 - Using this web page, the following facilities should be available.
 - Call should be started,
 - Missed calls should be seen,
 - Reminders can be set,
 - Private speed dial list should be created by accessing common pool and all internal numbers through phonebook,
 - Call Forwarding should be set according to day night modes,
 - Call records should be seen,
 - Conference room should be managed.
 - User web page should be dynamic so user should not need to refresh page to see new events like missed calls etc.
- **VOIP Parameters**
 - The IP based EPABX call switching for internal calls (i.e., limited to a single location) should be based on the G.711 uncompressed PCM standard, but WAN calls outside the location may use the G.711, G.729A/B compression algorithm.
 - The IP based EPABX system should be fully compliant to VOIP standards like H.323, SIP (Session Initiation Protocol).
 - The offered system should support both H.323 Trunk as well as
 - The IP based EPABX system must support Network Time Protocol (NTP) to synchronize the system data/time of network devices.
 - The SIP proxy, SIP registrar should be inbuilt in the system and should support any SIP compliant Hard Phones or Soft Phones.

- The IP based EPABX system be enabled with the QOS features for the VOIP implementation it should be compliant with both QOS standards (layer 2 – 802.1 p/q) and layer 3 – diffserv/tos)
- The system must be enabled with Echo Cancellation mechanism in IP Telephony to improve voice quality.
- Session Traversal Utilities for NAT (STUN) method should be supported by the system.
- Media Gateway /IP PBX must be standard rack-mountable (19”) solution having universal-slots architecture for flexibility in putting in any type of interface cards/modules for Analog & Digital Subscriber & Trunk. The IP PBX/MGW and its supporting cards must be from the same OEM. FXO/FXS based gateway solutions will not be considered. Vendor should offer the same GW Model at all the locations in such a way that, it should be possible to interchange the peripheral and Control cards between the Gateway locations.
- Media Gateway must have SELF SURVIVABILITY. Media Gateway(s) shall have IP connectivity to Core Servers of IP based EPABX system. Under normal circumstance Media Gateway(s) shall work in conjunction with or under the control of Core Servers as an integral part of IP based EPABX system. However, under isolation/disconnection condition (at IP connectivity level) of Media Gateway from Core Servers of IP based EPABX system, the Media Gateway shall support survival mechanisms that allow it to maintain 100% of the telephony services for its subscribers /trunks. Once the IP connectivity between Media Gateway & Core Servers is restored back, the Media Gateway shall work in conjunction with Core Server(s).
- All the Cards such as Analog/Digital Subscriber Card, VOIP Card, and Digital Phones etc must be interchangeable between all Gateway locations. Vendors to strictly quote for the same family of IP PBX/Gateway so that cards can be interchanged between the Gateways based on the need.
- The Media Gateway/EPABX must work on 48VDC normal with positive grounded and supply voltage varying from 42 to 58 Volts. The Gateway must have /PSU card which shall be able to work directly on AC Mains as well as option of working on external Float cum Boost Chargers (FCBC).
- Media Gateway should have modular architecture with the ability to stack multiple gateways in a single location. One or more such stacks should be placed in each location under the same Core Server control.
- Media Gateway should be able to restart automatically & shall support providing 100% of telephony service without human intervention at Media Gateway as well as at Core Server level when the input power supply to the Media Gateway is resumed after complete power failure, even under the failure of IP connectivity with Core Servers of IP based EPABX system.
- The cards and slots must be universal and interchangeable without switching off the exchange
- **IP PBX Features**
 - MOBILE TWINNING: The System must allow a Parallel ringing of Extn and Mobile phone.
 - The proposed system should be capable to provide the following features /facilities to the subscribers through user-friendly system programming.

- Abbreviated dialling
- Alternating between parties (broker call)
- Appointment reminder
- Assigned night answer for Trunks.
- Automatic call back on Busy trunk/network
- Automatic call back on free/busy extension
- Automatic lockout of faulty lines
- Boss-Secretary feature- digital and IP subscribers.
- Call by name and number from the digital & IP station
- Call forwarding to extension or hunting group, voice mail, operator, paging, etc.
- Call Forwarding (Internal and External) – no answer / busy / immediate / fixed / variable
- Call Park
- Call Pickup from any extension (individual and in a group)
- Call transfer
- Camp on busy extension/line
- CLI on the selected terminal.
- Choice of supervisory tones or voice announcements.
- Class of service changeover by station/operator/administration.
- Digit suffixing / prefixing – For the incoming calls, either from other exchanges or trunk, it shall be possible to insert/suppress at least 6 number or more of digits.
- Direct Inward Dialling supporting DP (dial pulse)/ DTMF (dual tone multi frequency) / mixed
- Directory Services (System should support minimum 10000 entries – name and numbers).
- Do not disturb
- Emergency call – by dialling a code (can be single digit) the user should be able to be routed to an emergency destination: external, internal, or attendant.
- Executive Override.
- Group Hunting
- Hold facility
- Hot-line services on extensions and trunks individual directory internal/external
- It shall be possible to suppress or add digits for outgoing calls.
- Last number redials
- Local and external call
- Mobile class of service for selected users or all users; this should include the mobility of the individual extension number across the network.
- Private incoming / outgoing trunk (Dedicated Trunks for Priority Users)
- Recorded announcement / music on hold (internal & external) for waiting party
- Selection of night service – at least 3 options should be selectable from console that is a line transfer to predefined extension, to voice mail, to a hunting group. It should also be possible to allocate each trunk line a different Night Destination.

- Special night answer points.
- Support the flexible numbering plan for dialling up to ten digits.
- Time of day barring of Local/STD/ISD calls from specified extensions.
- Timed reminder – wakeup call
- Toll / code restriction for trunk/tie or station-to-station calls.
- Auto attendant messages should be programmable.
- Extension to Cellular: The offered platform should provide embedded licenses (quantity as per bill of material) for users for achieving one-number accessibility by bridging calls that come to an office extension to any cellular phone.
- Dial tone, ringtone, busy tone, greeting tone should be programmable
- Conference: The system shall have 3-party conferencing. Moreover, there shall be a conference room feature.
- Conference Room: The offered system should have minimum 10 such conference rooms. To conference management, it shall be possible to monitor, mute/unmute, invite/disconnect the participants. Conference room shall be combination of IP, Digital and analog extensions) and shall be able to manage conference rooms through web-based interface. The offered system should have minimum 10 such conference rooms.
- The system shall support LCR (Least Cost Routing) feature. The system shall be able to analyses the numbers dialled by extensions and shall automatically divert them to pre-programmed trunk lines based on days of week or hours of day. Further, the system shall be able to automatically add/remove digits to/from dialled numbers.
- There shall be a common memory in which minimum 10000 numbers with 32 digits can be stored. It shall be possible to call these numbers by short dialling codes. If required, users having restricted authorization levels shall also be able to dial from common memory.
- In the system, there should be private pool where ten different numbers can be stored for each subscriber. One of them will be last dialled number. The subscriber will be able to call these numbers with short codes
- It shall be possible to connect GSM gateway/FCT interface device to the system's external lines and it shall be possible to make economic tariff mode calls to GSM numbers over this device. Moreover, it shall be possible to capture the called/ caller extension details and date and time details of GSM calls through the optional CRL (Call Record Listing) software. The offered system should have the option to connect 8 GSM Trunks/channel for Main office location
- GSM lines should support Call Back feature like trunk lines. If an extension of the system calls a GSM number and if GSM number misses that call, when GSM number calls back the missed number, the system should automatically divert this call to original caller (the extension who made the call).
- **Numbering Plan**
 - 1 to 8 Digits or More
- **System Management**
 - Access to the system should be secure. To access over IP network, system should only allow secured access mechanism like SSH and HTTPS.

- There should be provision of defining password aging, one-time passwords. Provision shall be available to bar unauthorized user to connect to the system. The system should monitor and report the following types of security violations like Login violations, etc
- All management functions like: System Configuration, Programming, Fault/Alarm management, System database backup, Accounting/Logging of traffic / calls etc. for the connected Media Gateway shall be provided remotely from the Core Server. It should not require separate login to Media Gateway.
- It shall be possible to connect IP-PABX system to any LDAP protocol-based server (including windows active directory) to get the directory information. IP-PABX shall use any standard directory protocol (LDAP etc.) or propriety protocol to send the directory to its IP phone users. The supplied IP phones shall support directory search and dial by name using this feature
- **Fault and Alarms**
 - It shall have the provision for instant fault information, provision of automatically identifying and isolating faulty extensions & trunks and capability for malicious call tracing.
 - It should also manage all the incidents and generate event/alarms reports informing date, hour & severity level.
 - This module must be able to centralize the alarms and events of the total system (including remote units). The system should also have provision for configuring of automatic email alerts for notification of faults to predefined Maintenance Staff.
 - A single incident of fault/failure in any of the critical resource elements of EPABX system shall not disrupt/affect all its extension & trunk telephony services.
- **Call Buffer Capacity - Native**
 - The Gateway must have its native capacity to store details of all incoming and outgoing calls up to a minimum capacity of 1.25 lac calls.
- **IPV4 and IPV6 Support**
 - The GW must support IPV 4 and IPV 6 from Day 1 and corresponding TEC certificate must be attached based on GR.
 - The hardware architecture of the IPPBX system shall be of latest and IPv4 and IPv6 ready from day one.
 - It shall be possible to assign IPv6 addresses to the system, as well as IPv4 addresses.
 - The system shall be capable of directly responding to IPv6 requests (establishing a call over IPv6, IPv6 supported IP telephone operation etc.) without requiring any converters.
 - The system shall also support hybrid IP networks in which both IPv6 and IPv4 protocols are used. The system shall be able to communicate over IPv4 and IPv6 networks, simultaneously
- **TDM & IP Support**
 - The Gateway must Support Analog CO, GSM Trunks ISDN PRI Trunks, and SIP Trunks.
 - The Gateway must have universal slots to support Analog, Digital and IP Extensions

- **Integrated GSM**
 - The gateway must support integrated card-based GSM Trunks with minimum 2 ports per card or more
- **Certification**
 - The offered model of IP based EPABX system should have approval from TEC for interfacing with PSTN SIP Trunking with Ipv4 & Ipv6 as per GR number TEC/GR/SW/PBX-005/01/SEP-16 for IP PBX with Media Gateway.
 - Integrated Voice Mail Card (In the main gateway unit) and Voice Logger
 - Capacity should be 16 or more channels per card
 - It should be inserted in the Main Gateway Unit and also interchangeable with other Gateways
 - Minimum 1000 Voice Mail Boxes could be programmed
 - Auto Attendant should be available with minimum 16 different types of announcements
 - 4 Channels IVR must be part of this solution
 - The system shall answer the incoming call & guide the caller through a voice guidance menu of various options to choose extension, operator, or directory service.
 - It must be possible to customize the announcements.
 - The system should have in Skin Voice logger for conversation recording.
 - The system should be supplied with min 4 Port Voice logger. The system shall have dedicated to automatic voice recording (voice logger) of pre-defined user (all types of extension Analog, Digital and IP) or trunk groups (Analog CO, PRI or SIP Trunk) or a combination of user/trunk groups (16 channels min.).
 - Voice logger also record internal calls (extension to extension). Voice records in the system shall be sent to an e-mail address as wav attachments.
 - It should be possible to record conversations on an HDD or USB memory to be directly connected to the system.
 - It should also be possible to store conversations on a storage device on the IP network. If storage disk on IP network is full or about to be full, alarm should be sent by system via e-mail.
 - Before a call to be recorded begins, the system shall automatically playback an announcement that the conversation will be recorded. It shall be possible to change this announcement by loading a wav file to the system
- **Integrated Audio Conference**
 - The solution must have integrated Conference facility with minimum 30 party Audio conference in any combination of Trunks and extensions
 - It must be possible to have multiple simultaneous conferences of 30 parties each
 - It must be possible to define Virtual Conference Rooms which shall be PIN protected for Senior Officers
 - It should support web-based GUI tool to manage this conference and allow multiple concurrence log in.

1.7.6 Technical Specifications of IP Phone

- SIP phone should be from the same OEM of IP telephony system.

- Two SIP accounts
- 320 x 240 Color Display
- Full-duplex hands-free speakerphone
- HD voice: HD handset, HD speaker
- One touch speed dialling.
- Hands free operation.
- Ring volume control.
- Speaker volume control.
- Should have Headset Jack
- Message waiting indication LED.
- Call Log - Missed Call, Called & Dial Number Details at least 100 No's
- Should support alternate server discovery in case the primary server fails.
- Should support Local & Remote phone book, should support LDAP
- Should have an integrated 2-port 10/100 / 1000 T Ethernet ports switch to allow connection of a PC directly to it and no separate cabling should be required for this. Should support IPv4 & IPv6
- Static/DHCP/PPPoE
- G.711, G.722, G.723, G.726, 729, iLBC, Opus
- SIP v1 (RFC2543), v2 (RFC3261), SRTP/ HTTPS/ TLS, 802.1x, Transport Layer Security (TLS)
- DTMF: In-Band, RFC2833, SIP Info
- It should have PoE 802.3af class 2.
- Must be of OEM make Only as of IPPBX. Details of Make & Model to be furnished.

1.7.7 Passive Components

- **Structural/generic cabling system manufacturer**
 - Please find below a summary of minimum requirements for manufacturers of the proposed structural cabling system. These requirements must be demonstrated with relevant certificates and manufacturer's representations.
 - **ISO 9001**
 - ✓ Structural cabling manufacturer must pursue ISO 9001 quality assurance system which must be in place for at least 5 years and must be demonstrated with relevant Certificate.
 - **ISO 14001**
 - ✓ Structural cabling manufacturer must feature a valid ISO 14001 certificate regarding: Design, development, production and supply of information and data management solutions that enable infrastructure owners to effectively plan, purchase, implement, secure, and manage their own physical layer infrastructure throughout its lifetime.
 - **RoHS Directive**
 - ✓ All structural cabling components offered by the manufacturer must conform with the RoHS directive (RoHS – Restriction of use of hazardous substances) 2002/95/EC of the EUROPEAN PARLIAMENT and of the COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment with amendments (2005/747/EC of 21 October 2005) as well as with

the Regulation of the Minister of Economy of 6 October 2004 (Journal of Laws No. 229 item 2309 and 2310) on specific requirements regarding the restriction of the use of certain substances in electronic and electrical equipment that may have a negative impact on the environment.

- **Structural/generic cabling system**
 - Please find below a summary of minimum requirements for the proposed structural cabling system.
 - These requirements must be demonstrated with relevant certificates and manufacturer's representations.
- **Uniformity of components**
 - All passive components of structural cabling must feature the name or trademark of the same cabling manufacturer and originate from a single manufacturer for the complete system.
 - Elements from different manufacturers must not be installed on the transmission path, this is concern to transmission cables.
- **Passive cable Warranty scheme**
 - The implemented structural cabling must be subject to a 25-year System Performance and Application Assurance Warranty certificate issued by cabling manufacturer.
 - The following Warranties must be available during that period:
 - ✓ **Component warranty**
 - ❖ All components of the certified system will be free from material and workmanship defects, provided they are properly assembled and used. If any component in the Certified Cabling System is found to be defective and prevents correct transmission of electrical signals, the manufacturer will repair such components or replace them with new components to enable the transmission of such signals.
 - ✓ **System operation warranty**
 - ❖ Connections/channels of the Certified Cabling System will meet performance parameters according to the category to which the certificate applies.
 - ❖ Should performance of the Certified Cabling System prove to be non-conforming with the category to which the certificate applies (based on results of test procedures as per standards), the manufacturer will repair or replace the components to ensure performance conformity with the certificate.
 - ✓ **Warranty for applications**
 - ❖ The Certified Cabling System will be free of defects that prevent operation of applications and protocols as per relevant standards within the performance category of the entire transmission path to which the certificate applies.
 - ❖ This applies to applications/protocols recognized by IEEE, ANSI and ATM Forum and intended specifically for transmission using the cabling defined in TIA /EIA/ 568, ISO IEC 11801, EN 50173.
 - ❖ Should the Certified Cabling System prevent the end user from using the application/protocols as per system performance

category, to which the certificate applies, the manufacturer will diagnose the problem and repair or provide new components that will ensure effective transmission of these applications and protocols.

- **Reviews of independent laboratories**

- Structural cabling must be supported by positive feedback from an independent testing laboratory on the compliance with minimum structural cabling standards (Permanent Link and Channel).
- Detailed requirements for these documents are included below in the specification for individual transmission elements.

- **Contractor**

- The installation of structural cabling must be performed by a company with valid qualifications and a certificate issued by the manufacturer of structural cabling. The document mentioned above must be attached to the offer in this tender procedure.
- Installer's certificate must not be more than two years old. Extension of the authorization for subsequent period is made by the cabling manufacturer based on installer's application and following retraining.
- The contractor must hire at least two installers with cabling manufacturer's authorization, covering the design, performance, supervision, measurements, and qualification to be covered by the warranty. It must be confirmed with registered certificates issued by the manufacturer of the offered structural cabling.

- **Horizontal copper cabling Specification**

Technical Specification		Compliance YES / NO
CAT6 A 10G Shielded LSZH U/FTP Cable		
The cable is constructed of 4 Aluminium screened pairs and a drain wire. Cable should minimize alien crosstalk, provides excellent signal isolation, and provides superior electromagnetic interference (EMI) protection.		
System is compliant with the latest ISO/IEC 11801 A1.1 draft and ratified TIA/EIA 568-B.2-10 for the support of 10GBASE-T.		
ETL verified to TIA/EIA-568-B.2-10 Category 6A standard		
Commercial Standards:	ISO/IEC 11801 amendment 2:2010 Class EA, TIA/EIA-568-C.2 Category 6A, IEC 61156-5, ETL independent testing, EN50288-6-1 and PoE++ IEEE 802.3bt Standards	
Manufacturer	All passive cabling must be from same OEM (UTP and Fiber) & OEM should have minimum 10 Years of presence in India in same business and should be ISO Certified and Restrictions to supply the product manufactured from country which shares a land border with India and recommend to supply make in India product. The material shall be	

Technical Specification		Compliance YES / NO
	rejected without any further investigation, if the proposing material had been rejected by any of Govt Organization (Employer) projects like AAI, Defence, Railway, Metro, Ministry of India Legislative etc since last 10 years.	
Fire Propagation Test	IEC 60332-1	
Application	IEEE 802.3 10GBASE-T 10Gb/s, IEEE 802.3 1000GBASE-T 1Gb/s, TIA/EIA-854 1000BASE-TX 1Gb/s, ATM 155Mb/s 155Mb/s	
Operating Temperature	Operation: --20°C to +70°C	
	Installation: 0°C to +50°C	
Conductor Size	23AWG / Primary Insulation: Polyolefin/Foamed Polyethylene	
Screen material	Laminated Aluminium	
Sheath Type: LSOH	LSOH - Low Smoke Zero Halogen	
Screen	Each pair enclosed in laminated aluminium foil	
Drain Wire	Tinned Copper	
Electrical Characteristics		
DC Resistance	$\leq 9.38\Omega/100m$	
Propagation Delay:	$514 + 36f^{1/2}$ nS/100m max @1-500 MHz	
Mean Impedance:	$100 \pm 15\Omega$	
Capacitance	Nom.< 5.6nF/100m	
Propagation Delay Skew:	45 nS/100 max @ 1-500 MHz	
Coupling Attenuation:	45dB min @30-100 MHz 40-20 Log (f/100) @ 100-500 MHz	
Voltage Rating:	72V dc maximum	
PoE Power	IEEE 802.3bt from Type 1 to Type 4, and PoE+, HD Base-T PoH up to 100W RP3 compliant as defined by EN 50174-2:2018, ISO/IEC 14763-2:2019 and AS/NZS 14763.2:2020	
CAT6 A 10G Unloaded Patch Panel with Rear Cable Manager		
RJ45 I/O Compatibility	Should be compatible with CAT6A 10G Shielded Jack	
Material	CRS - Cold Rolled Steel (Thickness - 1.5mm) with ROHS Compliant All Information Outlets (CAT6A – RJ45) IO's in Patch Panel Side shall be Tool	

Technical Specification		Compliance YES / NO
	less crimping. Tool crimping shall be rejected.	
Dimension	19" Width, 1U Height / 1.75Inch for 24Port Straight and Angled and 2U Height / 3.5Inch for 48Port Straight and Angled Panel	
Cable Manager	Flat type Perforated Metal Rear Cable Manager (Iron or Steel Rod will not be accepted)	
	If Rear Cable Manager is not part of the Unloaded Panel, please share Rear Cable Manager with Price and Data Sheet	
Labels	Should include labels and clear label covers at the front and back	
CAT6 A 10G Shielded Jack		
Jack Construction	Should be 360Degree Shielded Metal housing	
Standards	TIA-568-C.2 Augmented CAT6A, ISO 11801 Amd 1 Class EA, IEC 60603-7, FCC Subpart F 68.5	
Approval	ETL independent testing and UL-1863 Approval required	
Mechanical Characteristics	Operating Life: Min 750 insertion cycles	
Electrical / Optical Characteristics	Interface Resistance: 20m Ohms	
	Initial Contact Resistance: 2.5m Ohms	
	Insulation Resistance :> 100M Ohms	
Dust Cover	Shad cover the RJ45 interface to avoid dust & Contaminants	
Should have ROHS Compliant		
CAT6A Shielded Patch Cord -1/ 2 /3 mtr length		
Cable - Conductor Size	23AWG Stranded bare copper with Pre-Terminated with RJ 45 Plug	
Characteristics - Cable		
Screen material:	Aluminium/polyester shield with tinned copper drain wire	
Max Outer Diameter	6.5mm	
Temperature Range:	-20°C to +60°C	
Characteristics - Plug		

Technical Specification		Compliance YES / NO
Operating Life: Minimum 750 insertion cycles	Min 750 Insertion cycles	
Contact Material: Copper Alloy	Copper Alloy	
Contact Plating: 1.25 micrometres Au/Ni	1.25 micrometres Au/Ni	
RJ45 Plug dimensions compliant with	ISO/IEC 60603-7 and FCC 47 Part 68	
Standards	ISO / IEC 11801 2nd Ed Amd 1 Class EA, TIA-569-C.2 CAT6A, UL 1883; CSA C22.2	
Fire Propagation Tests	IEC 60332-1, IEC 61034-2	
Electrical Characteristics	Max Voltage: 150VAC (max)	
	Max Current: 1.5A @ 25°C	
Supports	High Speen 10G BASE-T Networks and backward compatible with 10/100/1000BASE-T Networks	
Single / Dual Face Plate		
Accommodates	Accommodates UTP, STP jacks	
Accommodates	Accommodates UTP, STP Data gate jacks Accommodates single bezel Fibre modules	
	Accommodates media configurable modules	
Material	VE10 ABS	
Web Site link	Enter global web site link for quoted model	
Fiber Backbone cabling Specification		
12/24 Core Multi mode OM4 Fiber cable		
Type of Fiber	12Core Multimode OM4 50/125-Micron Loose Tube outdoor armoured with ROHS Compliant	
Application	Outdoor/ Underground	
Jacket	UV Stabilized Polyethylene HDPE Sheath	
Armouring	Corrugated Steel Tape Armor (ECCS Tape), Thickness > 0.15mm	
Strength Member	Two Steel GI Wires	
Max. Crush Resistance	2000N	

Technical Specification		Compliance YES / NO
Max. Tensile Strength	1500N	
Fiber Protection	Polybutylene Terephthalate (PBT)	
Core wrapping	Polyethylene Terephthalate	
Standard	ITU G652.D - LWP, Low water peak	
Dimensions and Mass		
Mass (Nominal)	80 to 95 Kg/km	
Web Site link	Provide global web site line for quoted model	
24 Port Fiber Rack Mount Fiber Panel- LIU		
Rack Mount	19" rack mounted with 1U height, Sliding Drawer Type with 24 Cable entry/exit points with Lock and Key	
Material	Powder coated CRS / Robust Steel	
Accommodation and supports	Accommodation of multimode fibres	
	Capable of supporting 24 Fiber with SC interface	
Compatibility	Labelling for port identification, Fiber Management rings to accommodate excess fiber cordage behind the trough adapters and maintain fiber bend radius	
Optical Fiber Adapter Plates		
Features and Benefits	Adapter density ranges from 12 fibre per plate, allowing for 1U 24 fibre density. Available in a variety of connectors and performance levels, the Plates require no tools for installation	
	Snap Rivets – allows for easy installation and removal	
	100% Factory Tested – Guaranteed performance	
Commercial Standards	ISO/IC 11801, ANSI/TIA/EIA 568.B.3-2000, ANSI/TIA/EIA-492, TELECORDIA GR-409, ICEA-596	
24 Fiber Splice Holder		
Capable of supporting 45mm and 61mm Splice Protector		
Material	ABS - Halogen Free	
Base with Self-adhesive Pads of securing on a flat surface and a lid		
LC-LC Multi Mode OM4 OFC Patch Cords 50/125 Micron - 2 / 3 mtr		
Type of connectors	LC - LC LSOH - Low Smoke Zero Halogen	
Length	2 / 3 meters	

Technical Specification		Compliance YES / NO
Polishing	100% Factory polished and tested	
Insertion Loss	Less than 0.35dB per connector	
Attenuation	0.4dB/km over 1310nm to 1625nm	
Jacket colour	Industry Standard Colour - OS1/2 - Yellow, OM4-Aqua, OM2-Grey, OM1-Orange	
Temperature Range	-40 Degree C to +85 Degree C	
Buffer Diameter:	900µm	
Strength Member:	Aramid Yarn	
Jacket Material:	LSOH IEC 61034-1 & 2, IEC-60332-1, IEC-60754- 1 & 2	
Multi-Mode OM4 Pigtail		
Type of connectors	LC - LC LSOH - Low Smoke Zero Halogen	
Length	1.5 Mtrs	
Polishing	100% Factory polished, tested and Guaranteed Performance	

1.7.8 Modular Network Rack Specifications

- **42U Network Rack Server Room, HUB Room & TSP / ISP Rooms**
 - Rack 42U Height x 800mm Width x 800mm Depth.
 - Rack Frame should be robust and made of welded steel frame that offers strong and sturdy support for installation of 19" equipment and accessories.
 - Rack Frame made of Multi Folded Steel Profile and connected with Horizontal Profiles for Width and Depth.
 - Vertical Cable Reduce Channel for 19" Conversion with Loops for better cable routing.
 - The 19" mounting angles should be provided 2 nos. on front and rear side of the Rack. It should be adjustable full depth.
 - 19" Mounting Angles made up of Formed Steel 2mm Thickness with punched 10mm square holes and universal 12.7mm. 15.875. Alternating holes format offers for better mounting flexibility and maximizes usable mounting space.
 - Depth support channel with adjustable mounting slots.
 - Top and bottom Panel with ventilation and cable entry facility covered with rubber grommets.
 - Top Panel with Fan housing fixing provision, zero U Space.
 - Side Panel with Bottom Vented & Slam Latch
 - Front Door Lockable Toughened Glass / Perforated
 - Rear Door Lockable Vented / Perforated Single / Dual with 63% Perforation.
 - CAM Lock & Key for Single Door & 3 Point Lock for Dual Door.
 - Single Point Swing Handle Lock can be provided for both front & rear door.
 - Castor wheels (2 wheels with brake and rear without brake) with levellers or Base Frame
 - Static Load 750 kgs with castors & 1200 kgs with Base Frame / Plinth

- Rack shall be powder coated with 7 Tank pre-treatment process meeting ASTM standards. The Powder coating process shall be ROHS compliant.
- Powder coating thickness shall be 80 to 100 microns.
- The Color of the powder coat shall be RAL 7035 or Black.
- 100% assured compatibility with all equipment conforming to DIN 41494 / EIA 310-D standard. (General industrial standard for equipment)
- UL Certified & ISO 9001 & 14001.
- Equipment fixed Shelf 570mm or 470mm Depth.
- Modem Tray 19"/1U with 250mm Depth
- Keyboard Tray with Slides.
- Plinth Frame or Castor wheel set of 4 with Feet Brake.
- 4" Fan 90 CFM with Housing Unit on Top without Usable space of the Rack.
- Vertical Cable Manager with PVC Loops, 42U/100/100.
- The rack should be provided with front panel captive hardware set in a pack of 20 which helps in directly mounting the 19" equipment's.
- Horizontal Bar Earth, Cu, 16 x 3 x 485mm
- Earthing Strap
- Cable Manager 1U/19" Loop Type or Closed Type
- Power Distribution Box should be Single Phase with 1 x 12 nos. of Indian Round 5A Socket with 16Amp MCB and indicator with 3 Core Cable – 3 meters (terminated or unterminated 15A Plug Top).
- Power Distribution Box should be Single Phase with 1 x 12 nos. of Indian Round 5/15A Socket with 32Amp MCB and indicator with 3 Core Cable – 3 meters (terminated or unterminated IEC309 Plug Top).
- **32U Network Rack HUB Room & TSP / ISP Rooms – 800*800mm**
 - Rack 32U Height x 800mm Width x 800mm Depth.
 - Rack Frame should be robust and made of welded steel frame that offers strong and sturdy support for installation of 19" equipment and accessories.
 - Rack Frame made of Multi Folded Steel Profile and connected with Horizontal Profiles for Width and Depth.
 - Vertical Cable Reduce Channel for 19" Conversion with Loops for better cable routing.
 - The 19" mounting angles should be provided 2 nos. on front and rear side of the Rack. It should be adjustable full depth.
 - 19" Mounting Angles made up of Formed Steel 2mm Thickness with punched 10mm square holes and universal 12.7mm. 15.875. Alternating holes format offers for better mounting flexibility and maximizes usable mounting space.
 - Depth support channel with adjustable mounting slots.
 - Top and bottom Panel with ventilation and cable entry facility covered with rubber grommets.
 - Top Panel with Fan housing fixing provision, zero U Space.
 - Side Panel with Bottom Vented & Slam Latch
 - Front Door Lockable Toughened Glass / Perforated
 - Rear Door Lockable Vented / Perforated Single / Dual with 63% Perforation.
 - CAM Lock & Key for Single Door & 3 Point Lock for Dual Door.
 - Single Point Swing Handle Lock can be provided for both front & rear door.

- Castor wheels (2 wheels with brake and rear without brake) with levellers or Base Frame
- Static Load 750 kgs with castors & 1200 kgs with Base Frame / Plinth
- Rack shall be powder coated with 7 Tank pre-treatment process meeting ASTM standards. The Powder coating process shall be ROHS compliant.
- Powder coating thickness shall be 80 to 100 microns.
- The Color of the powder coat shall be RAL 7035 or Black.
- 100% assured compatibility with all equipment conforming to DIN 41494 / EIA 310-D standard. (General industrial standard for equipment)
- UL Certified & ISO 9001 & 14001.
- Equipment fixed Shelf 570mm or 470mm Depth.
- Modem Tray 19"/1U with 250mm Depth
- Keyboard Tray with Slides.
- Plinth Frame or Castor wheel set of 4 with Feet Brake.
- 4" Fan 90 CFM with Housing Unit on Top without Usable space of the Rack.
- Vertical Cable Manager with PVC Loops, 42U/100/100.
- The rack should be provided with front panel captive hardware set in a pack of 20 which helps in directly mounting the 19" equipment's.
- Horizontal Bar Earth, Cu, 16 x 3 x 485mm
- Earthing Strap
- Cable Manager 1U/19" Loop Type or Closed Type
- Power Distribution Box should be Single Phase with 1 x 12 nos. of Indian Round 5A Socket with 16Amp MCB and indicator with 3 Core Cable – 3 meters (terminated or unterminated 15A Plug Top).
- Power Distribution Box should be Single Phase with 1 x 12 nos. of Indian Round 5/15A Socket with 32Amp MCB and indicator with 3 Core Cable – 3 meters (terminated or unterminated IEC309 Plug Top).
- **12U Network Rack Security Cabin – 600*600mm**
 - Rack 12U Height x 600mm Width x 600mm Depth.
 - Rack Frame should be robust and made of welded steel frame that offers strong and sturdy support for installation of 19" equipment and accessories.
 - Rack Frame made of Multi Folded Steel Profile and connected with Horizontal Profiles for Width and Depth.
 - Vertical Cable Reduce Channel for 19" Conversion with Loops for better cable routing.
 - The 19" mounting angles should be provided 2 nos. on front and rear side of the Rack. It should be adjustable full depth.
 - 19" Mounting Angles made up of Formed Steel 2mm Thickness with punched 10mm square holes and universal 12.7mm. 15.875. Alternating holes format offers for better mounting flexibility and maximizes usable mounting space.
 - Depth support channel with adjustable mounting slots.
 - Top and bottom Panel with ventilation and cable entry facility covered with rubber grommets.
 - Top Panel with Fan housing fixing provision, zero U Space.
 - Side Panel with Bottom Vented & Slam Latch
 - Front Door Lockable Toughened Glass / Perforated
 - Rear Door Lockable Vented / Perforated Single / Dual with 63% Perforation.

- CAM Lock & Key for Single Door & 3 Point Lock for Dual Door.
- Single Point Swing Handle Lock can be provided for both front & rear door.
- Castor wheels (2 wheels with brake and rear without brake) with levellers or Base Frame
- Rack shall be powder coated with 7 Tank pre-treatment process meeting ASTM standards. The Powder coating process shall be ROHS compliant.
- Powder coating thickness shall be 80 to 100 microns.
- The Color of the powder coat shall be RAL 7035 or Black.
- 100% assured compatibility with all equipment conforming to DIN 41494 / EIA 310-D standard. (General industrial standard for equipment)
- UL Certified & ISO 9001 & 14001.
- Equipment fixed Shelf 570mm or 470mm Depth.
- Modem Tray 19"/1U with 250mm Depth
- Keyboard Tray with Slides.
- Plinth Frame or Castor wheel set of 4 with Feet Brake.
- 2" Fan 90 CFM with Housing Unit on Top without Usable space of the Rack.
- Vertical Cable Manager with PVC Loops, 9U/100/100.
- The rack should be provided with front panel captive hardware set in a pack of 5 which helps in directly mounting the 19" equipment's.
- Horizontal Bar Earth, Cu, 16 x 3 x 485mm
- Earthing Strap
- Cable Manager 1U/19" Loop Type or Closed Type
- Power Distribution Box should be Single Phase with 1 x 6 nos. of Indian Round 5A Socket with 16Amp MCB and indicator with 3 Core Cable – 3 meters (terminated or unterminated 15A Plug Top).
- Power Distribution Box should be Single Phase with 1 x 6 nos. of Indian Round 5/15A Socket with 32Amp MCB and indicator with 3 Core Cable – 3 meters (terminated or unterminated IEC309 Plug Top).
- **9U Network Rack Security Cabin – 600*600mm**
 - Rack 9U Height x 600mm Width x 600mm Depth.
 - Rack Frame should be robust and made of welded steel frame that offers strong and sturdy support for installation of 19" equipment and accessories.
 - Rack Frame made of Multi Folded Steel Profile and connected with Horizontal Profiles for Width and Depth.
 - Vertical Cable Reduce Channel for 19" Conversion with Loops for better cable routing.
 - The 19" mounting angles should be provided 2 nos. on front and rear side of the Rack. It should be adjustable full depth.
 - 19" Mounting Angles made up of Formed Steel 2mm Thickness with punched 10mm square holes and universal 12.7mm. 15.875. Alternating holes format offers for better mounting flexibility and maximizes usable mounting space.
 - Depth support channel with adjustable mounting slots.
 - Top and bottom Panel with ventilation and cable entry facility covered with rubber grommets.
 - Top Panel with Fan housing fixing provision, zero U Space.
 - Side Panel with Bottom Vented & Slam Latch
 - Front Door Lockable Toughened Glass / Perforated

- Rear Door Lockable Vented / Perforated Single / Dual with 63% Perforation.
- CAM Lock & Key for Single Door & 3 Point Lock for Dual Door.
- Single Point Swing Handle Lock can be provided for both front & rear door.
- Castor wheels (2 wheels with brake and rear without brake) with levellers or Base Frame
- Rack shall be powder coated with 7 Tank pre-treatment process meeting ASTM standards. The Powder coating process shall be ROHS compliant.
- Powder coating thickness shall be 80 to 100 microns.
- The Color of the powder coat shall be RAL 7035 or Black.
- 100% assured compatibility with all equipment conforming to DIN 41494 / EIA 310-D standard. (General industrial standard for equipment)
- UL Certified & ISO 9001 & 14001.
- Equipment fixed Shelf 570mm or 470mm Depth.
- Modem Tray 19"/1U with 250mm Depth
- Keyboard Tray with Slides.
- Plinth Frame or Castor wheel set of 4 with Feet Brake.
- 2" Fan 90 CFM with Housing Unit on Top without Usable space of the Rack.
- Vertical Cable Manager with PVC Loops, 9U/100/100.
- The rack should be provided with front panel captive hardware set in a pack of 5 which helps in directly mounting the 19" equipment's.
- Horizontal Bar Earth, Cu, 16 x 3 x 485mm
- Earthing Strap
- Cable Manager 1U/19" Loop Type or Closed Type
- Power Distribution Box should be Single Phase with 1 x 6 nos. of Indian Round 5A Socket with 16Amp MCB and indicator with 3 Core Cable – 3 meters (terminated or unterminated 15A Plug Top).
- Power Distribution Box should be Single Phase with 1 x 6 nos. of Indian Round 5/15A Socket with 32Amp MCB and indicator with 3 Core Cable – 3 meters (terminated or unterminated IEC309 Plug Top).

Note: The successful Bidder / Contractor shall submit the technical compliance of each equipment technical requirement as prescribed in the tender technical specification while submitting the Technical Datasheet Sheet (TDS) submission for approval of Consultant. The TDS shall not be accepted / reviewed and the same shall be rejected if the data shall be submitted without compliance sheet. Each equipment technical specifications shall be picked from the technical specification and the same shall be attached with respect to the equipments. This is applicable for entire equipments of ELV System.

TECHNICAL SPECIFICATIONS FOR WATER (DOMESTIC & RECYCLED) SUPPLY SYSTEM

CONTENTS

1.1 General Requirements	4
1.1.1 General Scope of Works:	4
1.1.2 Design Philosophy	5
1.1.3 Applicable codes	6
1.2 Pipe Trench Excavation	8
1.2.1 General	8
1.2.2 Trench Excavation Generally	9
1.2.3 TRIAL PITS OR TRENCHES	9
1.2.4 TRENCH EXCAVATION IN ROADS AND FOOTPATHS	10
1.2.5 TRIMMING TRENCH EXCAVATIONS	10
1.2.6 DISPOSING MATERIAL FROM TRENCH EXCAVATIONS	11
1.2.7 OTHER STRUCTURES ALONG THE PIPELINE	11
1.2.8 BEDDING	11
1.2.9 BACKFILLING	13
1.3 PIPE MATERIAL – HDPE PIPES	13
1.3.1 General	13
1.3.2 Grade of Material	14
1.3.3 Anti-oxidant	14
1.3.4 Testing of pipes during manufacturing	14
1.3.5 Detectability	16
1.3.6 Specials And Fittings	16
1.3.7 Handling, Transportation Storage and Lowering of Pipes	17
1.4 PIPE MATERIAL – DI PIPES	20
1.4.1 General	20
1.4.2 Coating	21
1.4.3 Inspection and Testing	23
1.4.4 Marking	23
1.4.5 Packing and Transport	23
1.4.6 Packing for DI Specials	24
1.4.7 Specials for Ductile Iron pipes	24
1.4.8 Lubricant for Ductile Iron Pipes	25
1.4.9 Specifications for Laying and Jointing of Pipeline System for Water Supply	25
1.4.10 Pillars for ductile iron pipes	27
1.4.11 Thrust Block	28

1.4.12	Supply of Ductile Iron Pipes	28
1.4.13	Polyethylene Encasement	28
1.4.14	Measurement	28
1.4.15	Notes	29
1.5	Valves	30
1.5.1	Sluice Valve	30
1.5.2	Scour Valve	32
1.5.3	Air Valves	32
1.5.4	Pressure Reducing Valves	34
1.5.5	VALVE CHAMBERS	35
1.5.6	Technical Datasheets - Mechanical	35
1.6	Instrumentation and Control	42
1.6.1	Electromagnetic Water Meter	42
1.6.2	Technical Datasheets	44

1.1 General Requirements

1.1.1 General Scope of Works:

The Scope of Work for proposed domestic and recycled water (for HVAC, flushing and irrigation water) supply networks for TIDEL Park, Madurai under this contract includes but is not limited to the following in relation to the Design, supply, construction, testing, commissioning and comprehensive operation and maintenance period of 5 years including Two years of Defect Liability Period (DLP) from the date of successful commissioning of water supply system:

- a) All preliminary works such as site clearance in all types of conditions, marking of alignment etc. as described elsewhere in these specifications, for such work no extra payment shall be made to the Contractor. The Contractor is advised to inspect site and ensure the laying of pipeline before bidding to ascertain the quantum, specialized work and cost of such works and include this cost in their offer.
- b) Preparatory works such as confirmatory surveys, if contractor so desires including its approval.
- c) Excavation, dewatering, ramming, refilling, and disposal of surplus excavated soil for pipe trench.
- d) Supply, Safe storage and handling, laying, jointing, testing and commissioning of domestic and recycled water supply pipeline and distribution network including specials, appurtenances and bends as per the layout drawing. All labour and material for these works shall be arranged by Contractor.
- e) Supply, Installation & commissioning of the various valves at various places as per specifications.
- f) Supply, laying, jointing, testing and commissioning of Motorized Valves and Domestic/Bulk water meters with necessary arrangement at UGT Inlet Chamber.
- g) Supply, Installation, testing and commissioning of Level switches, Level controller with control panel.
- h) Providing pipe bedding in trenches as per typical drawings.
- i) Construction of valve chamber for above valves as per specifications and drawings.
- j) Construction of thrust blocks, anchor blocks, pipe supports as necessary.
- k) Cutting of roads after proper approval and making them good.
- l) Sectional hydrostatic testing of complete pipeline network.
- m) Commissioning and disinfection of complete pipeline network.
- n) Removal of defects in pipeline network and allied civil, mechanical, electrical and instrumentation works after inspection and/or testing.

- o) Submission of shop drawings/ fabrication drawings for review and approval of the Engineer-in charge for water supply network before starting the execution of works at site.
- p) Submission of As-built drawings and O&M Manual.
- q) Providing training to the staff (offsite and onsite) for operation and maintenance of water supply system.
- r) Repairs of all works as necessary during Defect Liability Period.
- s) Allied civil, mechanical, electrical & instrumentation works as mentioned in the bill of quantities and tender drawings.
- t) Compliance with SHE norms as specified by TIDEL Park conditions of contract.
- u) To take all safeguards to avoid accidents at site, prevent loss to other pipelines, telephone and electric cables and other property during all phases of working.
- v) Five-year Operation & Maintenance for water supply network and handing over activities on completion of project.
- w) All required spares and accessories shall be provided by Contractor till the project completion stage.

1.1.2 Design Philosophy

The potable water will be tapped from the Madurai Municipal water main. This water will be carried to the Underground Tanks (UGT). From the UGT, water will be pumped to overhead storage tanks through Galvanized Iron (GI-Class C) pipes. Onward water from overhead tank will be distributed to each floor by gravity and for top 3 floors by booster pumping.

The following components are envisaged in the domestic and recycled water supply and distribution system:

- Storage tanks of 200 KL for Domestic Water, 210 KLD for HVAC Makeup water, 50 KLD for irrigation water and 150 KLD for flushing water shall be provided at TIDEL Park.
- Pump house, pumps, valves, water meters and mechanical and electrical works at pumps.
- SCADA system for monitoring and control.
- A continuous system of supply is contemplated for the potable water distribution areas. Water is made available to the consumers throughout the day through the provision of UGT with 1 day storage capacity.
- Ductile Iron (DI-K9) pipes with internal cement mortar lining are proposed for the design of domestic water transmission main system. The minimum residual pressure of 5 m at the user end is considered for the network design.
- Recycled water will be made available from STP tertiary treatment of sewage. A reclaimed water distribution network is considered which will carry treated water from the STP to UGTs. And from UGTs water shall be distributed to various locations for intended uses such as:

- Flushing water network
- HVAC water network
- Irrigation water network
- Separate Irrigation water distribution network will provide to supply water for green area.
- The surplus treated water available can be used for other purposes like cleaning of roads, flushing of sewers etc.
- Recycled pipe network will be designed with same design criteria and for same parameters as that of Potable water.
- The pipe materials for flushing, HVAC and irrigation network are recommend as HDPE PE100 PN6 (IS 4984) based on maximum pressure expected. PE 100 is considered from minimum size 75 mm upto 90 mm. For isolated cases size may be vary based on design parameters (residual pressure and velocity).

1.1.3 Applicable codes

The manufacturing, testing, supplying, laying, jointing, and testing at work sites of HDPE pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In Particular, the following standards, unless otherwise specified herein, shall be referred. In all cases the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern. Other Codes not specifically mentioned here but pertaining to the use of HDPE pipes form part of these Specifications.

IS: 8329-2000	Centrifugally cast (spun) ductile iron pressure pipes for water, gas, and sewage.
IS: 12288-1987	Code of practice for use and laying of ductile iron pipes
IS: 14846-2000	Sluice valve and Air valve for water works purposes (50 to 1200 mm)
IS: 383	Tests specified for determining silt in sand and organic impurities
IS 2720: Part 7	Methods of test for soils for determination of water content-dry density relation using light compaction.
IS 460: part 1	Specification for test sieves: Wire cloth test sieves
IS:5312-2004	Check valve for water works purposes
IS: 5382 -1985	Rubber sealing rings for gas mains, water mains and sewers
IS: 779-1994	Water meters

IS 2401	The installation and maintenance of water meters
IS: 12820-2004	Dimensional requirements for rubber gaskets for mechanical joints and push on joint for use with cast iron pipes and fittings for carrying water, gas and sewage.
IS 9523-2000 /BS: EN 545	Specification for ductile iron fittings for pressure pipes for water, gas and sewage
IS:11906	Recommendations for cement mortar lining for cast iron, mild steel and ductile iron pipes and fittings for transportation of water
IS: 4984	High Density Polyethylene Pipes for Water Supply
IS: 2530	Methods of test for polyethylene moulding materials and polyethylene compounds
IS: 5382	Rubber sealing rings for gas mains, water mains and sewers. Methods for random sampling
IS: 7328	High density polyethylene materials for moulding and extrusion
IS: 7634	Laying & Jointing of Polyethylene (HDPE) Pipes
IS: 9845	Method of analysis for the determination of specific and/or overall migration of constituents of plastics material and articles intended to come into contact with foodstuffs
IS: 10141	Positive lists of constituents of polyethylene in contact with food stuffs, pharmaceuticals and drinking water.
IS: 10146	Polyethylene for its safe use in contact with foodstuff, Pharmaceuticals and drinking water.
IS 4905: 1968	Methods for random sampling
IS 8360 (part- I): 1977	“Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – General Requirements”
IS 8360 (part- II) :1977	“Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – Specific Requirements for 90 Deg. Tee”

IS 8360 (part- III) :1977	“Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – Specific Requirements for 90 Deg. Bends”
IS:3764	Excavation work Code of Safety
IS:456	Code of practice for plain and reinforced concrete
IS:638	Specification for sheet rubber jointing and rubber insertion jointing
IS:816	Code of practice for use of metal arc welding for general construction in mild steel
IS:1367	Technical supply conditions for threaded steel fasteners
IS:1500	Method for Brinell hardness test for metallic materials
IS:3658	Code of practice for liquid penetrant flow detection
ISO:4179	Ductile iron pipes and fittings for pressure and non-pressure pipelines Cement mortar lining
ISO 8179	Ductile iron pipes, fittings, accessories and their joints — External zinc-based coating

- CPHEEO Manual on Water Supply and Treatment, Ministry of Urban Development, New Delhi- March 2024
- NBC: 2016 (Part 9_Section-1) – National Building Code of India

1.2 Pipe Trench Excavation

1.2.1 General

Trench Excavation means excavation of trenches into which pipes are to be laid and the term pipes shall mean pipes of all kinds and for whatever purpose. The line and level of trenches shall be as shown on the Drawings or as may be required by the Engineer. Before commencing trench excavation, the route of the trench shall be pegged out accurately and the ground levels shall be agreed with the Engineer. Strong sight rails shall then be fixed and maintained at each change of gradient and at as many intermediate points as may be necessary. On these rails shall be marked the centre line and the level to which the excavation is to be carried out, such rails being not more than 35 metres apart.

1.2.2 Trench Excavation Generally

Trench excavation shall be carried out by such methods and to such lines, dimensions and depths as shall allow for the proper construction of the Works, provided always that, unless the Engineer permits otherwise, no Trench Excavation shall be less than 500 mm in width and no trench excavation for pipes larger than 200 mm diameter shall exceed the widths stated: -

- (i) Excavation in firm ground or soft rock, no shoring required $D + 400$ mm
- (ii) Excavation in soft ground or any conditions requiring shoring $D + 400$ mm
- (iii) Excavation in Rock $D + 1000$ mm

Where D is the outside diameter of the pipe in mm.

Notwithstanding the foregoing, any Hard Rock in Trench Excavation shall be so excavated that the clearance between the pipe when laid and the Hard Rock sides and bottom of the trench is kept to the minimum limits necessary to provide for the specified thickness of bedding, haunching and surround to the pipe. Any excavation outside these limits whether for working space or due to over break shall be held to be excess excavation.

The sides of Trench Excavation shall be vertical unless the Engineer permits otherwise, any widening or deepening of trench excavation necessary to accommodate curves, joints or bends in the pipe as shown on the drawings or when ordered by the Engineer shall be held to be 'general excavation' but that required by the contractor to provide extra working space for the construction thereof shall be held to be excess excavation.

For the purpose of measuring certain work in connection with trench excavation, "nominal limits" of trench excavation are stated hereof and any excavation outside these limits which has not been ordered by the Engineer, shall be held to be excess excavation.

No length of trench excavation shall be started until the pipes to be laid in that length are available on the Site.

1.2.3 TRIAL PITS OR TRENCHES

The Engineer may require trial pits or trenches be excavated well ahead of the trench excavation to such depths as he shall order to determine the alignment for the trench. Any further trial pits or trenches required by the Contractor to determine the position of underground services, sub-soils, drains or for any other reason shall be excavated and reinstated at the Contractor's expense.

The Contractor shall arrange for the refilling and reinstatement of trial pits or trenches to be carried out immediately after the required information is obtained. The reinstatement of the surfaces of trial pits or trenches shall be carried out to the approval of the Engineer.

1.2.4 TRENCH EXCAVATION IN ROADS AND FOOTPATHS

All Trench excavation and other work carried out within the limits of any road shall be completed as rapidly as possible and not more than half of the width of the carriageway shall be obstructed at a time. Road drains and grips shall be kept free from obstruction. In an event the contractor shall take special precautions, which shall include the continuous support of the sides of the excavation, from the time when excavation is begun until the refilling of the trench is placed, to ensure that there is no disturbance of the adjacent road or road foundation.

Where excavated material has temporarily been deposited on grass margin or road pavement, the margin or road pavement shall on completion of refilling be restored entirely to its original condition and left free from loose stones.

1.2.5 TRIMMING TRENCH EXCAVATIONS

When excavating to specified levels for trench excavation or to specified limits for the face of any structure therein required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing constructional work except where the Engineer permits otherwise. If the Contractor has excavated to within 150 mm above these specified levels or to within 150 mm of these specified limits before he is ready to able to commence the constructional work, he shall where required by the Engineer excavate further so as to remove not less than 150 mm of material immediately before commencing the constructional work and any such further excavation shall be held to be excess excavation.

Where no bedding material is specified to be laid beneath the pipe the bottom of trench excavations shall be carefully boned in and trimmed true to grade with the aid of a straight edge at least six metres long so as to ensure a continuous support for the pipes. The trench bottom shall then be pricked over with a fork and any stones or flints either likely to cause the pipe to bed unevenly or to damage the pipe and its coating or greater than 20 mm in size shall be picked out of the pipe bed and any holes so formed shall be filled in with soft material and trimmed to the correct level.

Where no bedding material is specified, all shattered and loose material shall be removed from the bottom of the Trench Excavation so that the bedding material rests on a solid and clean foundation.

1.2.6 DISPOSING MATERIAL FROM TRENCH EXCAVATIONS

For disposal of trench excavation material, please refer to TECHNICAL SPECIFICATION – CIVIL WORKS, Section 1 point no. 1.18 of technical Specification.

1.2.7 OTHER STRUCTURES ALONG THE PIPELINE

The Contractor shall carry out further excavation as may be necessary to accommodate structures such as anchor blocks and valve chambers. Such excavation shall include for disposal of surplus material and where appropriate, for backfilling round the structures.

1.2.8 BEDDING

The depth and type of bedding shall be as shown on the drawings or as directed by the Engineer. Where rock or boulders are encountered, the trench shall be trimmed to a depth of at least 250 mm below the level at which the bottom of the barrel of the pipe is to be laid and filled to a like depth with sand as shown on the drawings or as directed by Engineer.

The class of bed and surround to be used are indicated below:

Class of bed and surround	Brief description of bedding material
Class A	Mass Concrete
Class S	Well Graded Sand
Class N	Granular material

Class S bed and surround shall be used on all pipes unless otherwise specified or shown on the drawings.

The concrete to be used for Class A bedding and surround shall be M20 type. Class A bedding shall be used at all road crossings under the road and for a distance of 5 m back from the back edge of road or footpath.

Class N bed material shall only be used where the pipe trench is founded in hard rock or otherwise as directed by the Engineer. The sand shall be clean and well graded and free from topsoil, clay or vegetable matter and to the approval of the Engineer. If the sand supplied is unclean it shall be washed. In no case shall sand containing more than 3.5% by dry volume or 5% by wet volume of clay, loam or silt be accepted. Tests specified for determining silt in sand and organic impurities as described in IS 383 shall apply.

The graded granular bed material for use in Class S bedding and surround shall consist of durable gravel, crushed stone or disintegrated rock. Selected material excavated from the pipe trench may be used, provided it contains no topsoil, clay or vegetable matter and is to the approval of the Engineer. Any imported bed and surround materials shall be to the approval of the Engineer and shall be supplied with certification which gives details of its content, source and grading. In all cases the soluble sulphate and chloride content of the granular material shall not exceed 0.5 % and 0.06 % by weight respectively.

- a) Graded Material: The Contractor's method of grading the excavated material shall be to the approval of the Engineer. All Class S graded material shall pass through test sieves to IS 460 (Part 1) in the following proportions by mass:

Aperture Size	Percentage Passing
50 mm	100 %
37.5mm	90-100%
20.0mm	35-70%
14.0 mm	25-55%
10.0 mm	10-40%
5.0 mm	0-5%

- b) Construction of Class A bed and Surrounds: Class A bed and surround shall be constructed as indicated in the drawings.

Before placing concrete, the pipes shall be supported near each joint with a padding of compressive material on a precast concrete block. Concrete shall not be placed until the pipes have been jointed, inspected and tested. The concrete shall be placed to ensure full contact with the pipe barrel throughout its length.

The concrete shall be made discontinuous at flexible pipe joints by a diaphragm of fibre board or other compressible material of at least 20 mm thickness extending for the full area of the surround.

No concrete shall be placed around joints of a welded steel pipe until that length of pipe has passed a sectional hydraulic test.

- c) Construction of Class S bed and Surrounds: Class S pipe bed and surround shall be constructed as indicated in the Drawings.

The granular material shall be evenly spread over the full width of the formation and lightly compacted to a level slightly higher than level corresponding to the underside of the pipe barrel to allow for settlement of the pipe to the correct level. Following placement and jointing of the pipe further granular material shall be placed in the trench, special care being taken to fill under the sides of the pipes to ensure full contact with the barrel of the pipe. The backfill compacted material shall then be placed and compacted evenly on both sides of the pipe to a depth of 300 mm above crown of the pipe. Field joints which have not been tested shall be left exposed for a minimum length of 150 mm on each side of the joint.

Trench supports shall be withdrawn gradually in accordance with the progress of the fill with the provision that such withdrawal shall not prejudice the safety of the Works. The Contractor shall ensure that the material to the sides of the pipe is adequately compacted in layers having a maximum thickness of 150 mm and that the method of compaction used shall achieve not less than 95 % of the maximum dry density as determined from IS 2720: Part 7. After each section of the pipeline has passed the hydraulic test, the exposed joints shall be backfilled and compacted to the above Specification.

The same general requirements shall apply to Class N bedding.

1.2.9 BACKFILLING

For backfilling / Refilling please refer to TECHNICAL SPECIFICATION – CIVIL WORKS, Section 1 point no. 1.13.

1.3 PIPE MATERIAL – HDPE PIPES

1.3.1 General

The recycled water network (for flushing, HVAC and irrigation networks) pipes shall be of High-Density Polyethylene Pipes (HDPE) as per IS 4984 except mentioned otherwise. The material used for the manufacturing of pipes should not constitute toxic hazard, should not support microbial growth, should not give rise to unpleasant taste or Odour, cloudiness, or discoloration of water. Pipe manufacturers shall obtain a certificate to this effect from the manufacturers of raw material by any internationally reputed organization to the satisfaction of the Engineer- in -Charge.

1.3.2 Grade of Material

Raw material used to manufacture the HDPE pipes shall be 100% virgin PE compound or Natural black PE resin confirming to IS: 4984, IS: 7328 and ISO: 4427 for this a certification has to be obtained by the resin manufacturer as per clause 3.2.3 of IS: 4984. The resin proposed to be used for manufacturing of the pipes should also comply with the norms as per ISO 9080.

The specified base density shall be as prescribed in IS 7328. The MFR of the material shall be as prescribed in IS 2530. The resin shall be compounded with carbon black. The carbon black content in the material shall be as per IS 2530.

- The pressure rating of HDPE pipes and specials shall be of PN 6 confirming of IS: 4984.
- The colour of the HDPE pipe shall be confirming to IS4984:1995 or of ISO 4427:1996.
- Black colour for potable water and blue colour for non-potable water uses.
- Addition of not more than 10 percent of the manufacturer's own reworked material resulting from the manufacture of pipes is permissible, as per the clause 5.4 of IS 4984:1995. No other reworked or recycled material shall be used. The material to be used shall be clean and should be derived from the same resin as used for the relevant production.

1.3.3 Anti-oxidant

The percentage of antioxidant used shall not be more than 0.3 percent by mass of finished resin. The anti-oxidant used shall be physiologically harmless and shall be selected from the list given in IS 10141.

1.3.4 Testing of pipes during manufacturing

a) Visual appearance

The internal and external surfaces of the pipes shall be smooth, clean, and free from grooving and other defects. The ends shall be cleanly cut and shall be square with axis of the pipes. Slight shallow longitudinal grooves or irregularities in the wall thickness shall be permissible, provided that the wall thickness remains within the permissible limits.

b) Hydraulic characteristics

When subjected to internal pressure creep rupture test in accordance with the procedure given in Annex B of IS 4984, the pipes shall show no signs of localized swelling, leakage or weeping and shall not burst during the prescribed test duration.

The temperatures, duration of test and induced stresses for the test shall confirm to those specified in the Table 6 of IS 4984.

c) Length test

The length of straight pipe shall be 5 m to 20 m, as agreed between the manufacturer and the purchaser.

d) Melt flow rate

When tested from a composite sample of minimum three pipes as per IS 2530:1963, at 190deg C with nominal load of 5kgf.

e) Quality certificates

Quality assurance certificate as above for the raw material proposed to be used for the project, from one of the certifying agencies in India or other internationally reputed organization shall be submitted as per the direction of Engineer in Charge.

f) Pressure rating

The pressure rating of HDPE pipes and specials shall be of PE-100-PN-6 confirming to IS: 4984.

g) Dimensions and Tolerances

The pipe dimensions shall be as per the latest revisions and amendment of IS 4984:1995. The pipes up to diameters 110mm shall be supplied in coils of 100m length. The coils shall be as per the provisions of IS 4984:1995. Pipe beyond 110mm shall be supplied in straight lengths of minimum 6m to 12m as per Engineer- in - Charges instructions. The internal diameter, wall thickness, length and other dimensions of pipes shall be as per relevant tables of IS: 4984 for different class of pipes. Each pipe shall be of uniform thickness throughout its length.

h) Performance requirements

The pipe supplied should have passed the acceptance tests as per IS4984:1995. The manufacturer should provide the test certificates for the tests conducted, as specified in IS 4984:1995 along with supply of pipes. These tests can be performed in the in-house laboratory of the pipe manufacturer or at an approved laboratory. The Employer will fix the third party for inspection of pipes at factory as per the requirement. The cost of such inspection shall be borne by the contractor.

Each straight length of the pipe shall be clearly marked in inedible ink / paint on either end and/or for coils at every 5m as per the provisions of IS 4984:1995, the following information shall be provided on the pipe:

1. The manufacturer's name and/or trademark

2. Designation of the pipe as per IS.
3. Lot number / Batch number
4. Employer's mark as "BSCDCL".

The pipe manufacturer who is going to supply the pipe for the project has to have a valid BIS license to do so for the kind of pipes required for this project.

1.3.5 Detectability

HDPE Pipes should be detectable when buried underground, by providing a copper wire of 1.20mm+/-0.2mm dia, co extruded or firmly secured by self-adhesive tapes along the entire length of the pipes duly ISI marked or any other equivalent method enabling measurement/detectability from the top of ground including supply of 3 sets of such instrument to the SPV.

Copper wire shall have PE (Polyethylene) insulation, if laid separately and secured by self-adhesive tapes on the pipe. The insulation shall be free from voids and shall be strong enough to withstand mechanical and thermal stress of underground buried conditions. The thickness of the PE insulation shall not be less than 1.25mm or more, if specified in the relevant BIS Standards. The pipe shall generally meet the specifications as per IS 4984/ relevant ISO with latest amendments.

The engineer-in-charge reserves the right to witness all tests and the contractor shall provide all facilities, to the engineer in charge in this regard and shall inform sufficiently in advance to enable the engineer in charge to depute his representative to witness the same. HDPE pipes should preferably be with co- extruded copper wire.

1.3.6 Specials And Fittings

All HDPE fittings / specials shall be moulded for lower diameter up to 200mm dia and fabricated for other diameter in accordance with IS: 8360 (Part I & III). PE Injection moulded fittings shall be as per IS: 8008 (Part I to IX). All fittings / specials shall be fabricated, or injection moulded at factory only. No fabrication or moulding will be allowed at site, unless specifically permitted by the Engineer- in -Charge. Fittings will be electro-fusion welded on to the pipes or other fittings by use of heat fusion:

- HDPE bends shall be plain square ended conforming to IS: 8360 Part I & III Specifications. Bends may be fabricated by joining several small sections of pipes to reach the required angle.

- HDPE Tees shall be plain square ended conforming to IS: 8360 Part I & II Specifications. Tees may be equal tees or reduced take off tees. Tees may be moulded or fabricated from pipes elements.
- HDPE Reducers shall be plain square ended conforming to IS: 8008 Part I & VII Specifications. Reducer must be moulded.
- HDPE Stub ends shall be square ended conforming to IS: 8008 Part I & VII Specifications. Stub ends will be welded on the pipe. Flange will be of slip-on flange type as described below
- Slip-on flanges shall be metallic flanges covered by epoxy coating or plastic powder coating. Slip-on-flanges shall be conforming to standard mating relevant flange of valves, pipes etc. Nominal pressure rating of flanges will be PN 6

1.3.7 Handling, Transportation Storage and Lowering of Pipes

During handling, transportation, storage and lowering, all sections shall be handled by such means and in such a manner that no distortion or damage is done to the section or to the pipes as a whole. The following procedures should be followed so as to eliminate potential damage to pipes and fittings and to maintain maximum safety during unloading, lifting and lowering.

- Pipes must not be stored or transported where they are exposed to heat sources likely to exceed 60oC.
- Pipes shall be stored such that they are not in contact with direct sunlight, lubricating or hydraulic oils, petrol, solvents, and other aggressive materials.
- Scores or scratches to a depth of greater than 10% or more of wall thickness are not permissible; any pipes having such defects should be strictly rejected.
- HDPE pipes should not be subjected to rough handling during loading and unloading operations. Rollers shall be used to move, drag the pipes across any surface.
- Only polyester webbing slings should be used to lift heavy PE (>315mm) pipes by crane. Under no circumstances, chains, wire ropes and hooks are used on HDPE pipes.
- Pipes shall not be dropped to avoid impact or bump. If any time during handling or during installation, any damage, such as gouge, crack or fracture occurs, the pipe shall be repaired if so, permitted by the competent authority before installation.
- During coiling care should be taken to maintain the coil diameter at or above the specified minimum to prevent kinks. Coiling shall be done when the pipe attains

the ambient temperature from the extruder. In uncoiling or recoiling care should be taken so that sharp objects do not scour the pipe.

- When releasing coils, it must be remembered that the coil is under tension and must be released in a controlled manner. The end of the coil should be retained at all times, then the straps released steadily, one at a time. If the coil has bands at different layers of the coil, then they should be released sequentially starting from the outer layers. The amount of the energy locked up in the coil will depend on the size of the pipe, the SDR of the pipe, and the size of the coil.
- Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set.
- Bare coils shall be wrapped with hessian cloth for long distance (> 300Kms) transportation. The truck used for transportation of the HDPE pipes shall be exclusively used of HDPE pipes only with no other material loaded – especially no metallic, glass and wooden items. The truck shall not have sharp edges that can damage the Pipe.

a) Lowering and laying of pipes

- Each pipe shall be thoroughly checked for any damage before laying and only the pipes which are approved by the Engineer shall be laid.
- While installing the pipes in trenches, the bed of the trench should be level and free from sharp edged stones. In most cases, the bedding is not required, as long as the sharp and protruding stones are removed, by sieving the dug earth, before using the same backfill material. While laying in rocky and black cotton areas suitable bedding should be provided as per the specification for bedding.
- As HDPE pipes are flexible, long lengths of fusion-jointed pipes having joints made above ground can be rolled or snaked into narrow trenches. Such trenches can be excavated by narrow buckets.
- During the pipe laying of continuous fusion jointed systems, due care and allowance should be made for the movements likely to occur due to the thermal expansion/contraction of the material. This effect is most pronounced at end connections to fixed positions (such as valves etc.) and at branch connections. Care should be taken in fixing by finishing the connections at a time the length of the pipe is minimal (lower temperature times of the day.)
- For summertime installations with two fixed connection points, a slightly longer length of PE pipe may be required to compensate for contraction of the pipe in the cooler trench bottom.
- The final tie-in connections should be deferred until the thermal stability of the pipeline is achieved.
- The flexibility of polyethylene pipes allows the pipe to be cold bend. The fusion jointed PE pipe is also flexible as the plain Pipe. Thus, the total system enables

directional changes within the trench without recourse to the provision of special bends or anchor blocks. However, the pipe should not be cold bend to a radius less than 25 times the OD of the pipe.

- The Installation of flanged fittings such as connections to sluice/air/gate valves and hydrant tees etc., requires the use of stub ends (collars/flange adaptors complete with backing rings and gaskets. Care should be taken when tightening these flanges to provide even and balance torque.
- Provision should be made at all heavy fittings installation points for support (such as anchoring of the flange in the soil) for the flange joint to avoid the transfer of valve wheel turning torque on to the PE flange joint.
- PE pipe is lighter than water. Hence care should be taken of normal installations where there could be a possibility of flooding of the trench thus the trench shall be kept free of water till the jointing has been properly done.
- When flooded, some soil may lose cohesiveness, which may allow the PE pipe to float out of the ground. Several design checks are necessary to see if groundwater flotation may be a concern. Obviously, if the pipeline typically runs full or nearly full of liquid, or if groundwater is always below the pipe, flotation may not be a significant concern. In this case contractor has to design necessary weights by way of concrete blocks (anchors) so that the PE pipe does not float when suddenly the trench is flooded and the soil surrounding the pipe is washed away.

b) Jointing of Pipes

- Below 110 mm diameter: Push type compression joints.
- Equal and Above 110 mm diameter: Butt-fusion / Electro-fusion (Heat Fusion Process)

As in case if number of bends and joints are more electro-fusion joints shall be provided.

c) Welding Procedure

Joining between HDPE pipes and specials shall be done as per the latest IS: 7634 part II. Method of jointing between the pipes to pipes and pipes to specials shall be with electro fusion welding using automatic, hydraulically operated, superior quality electro fusion machines which will ensure good quality electro fusion welding of HDPE pipes.

d) Flanged Joints

Jointing of PE Pipes with fittings, valves, metal pipes, and where non-PE pipes are to be joined with PE pipes shall be carried out using Flanged joints. Flanges will be used to fit together elements of different materials such as valves (in cast or ductile iron) with HDPE pipes through the use of a flange adaptor. The joining consists of

slip-on metallic/polyethylene flanges with collar/stub ends. The Collar/stub-end shall be welded either by butt, socket or electro fusion - as per the latest Indian Standard or any International Standard. The nominal pressure rating shall be at least equal to the highest-pressure rating of the pipes or fittings to which they are attached, but with a minimum PN 6.

e) Gaskets For Flanged Joints

Gaskets for flanged pipe joints shall be of inside bolt circle type and the dimensions shall comply with BSEN 1514-2:2005 – Flanges and their joints.

The physical properties of gaskets shall comply with BS 7874:1998 (Method of test for microbiological deterioration of elastomeric seals for joints in pipework and pipelines for effects on water quality and resistance to microbiological deterioration). The Gaskets shall also comply with the relevant provisions in BS 7874:1998 for effects on water quality and resistance to microbiological deterioration. The Gasket material shall be EPDM/SBR and shall be of average hardness of 65-75.

The Gaskets shall be supplied by the manufacturer and shall suit for PN 10 flanges unless otherwise stated. Each gasket shall be marked clearly and durably in accordance with the following information in a manner that does not interfere with the sealing function of the gasket, complying with clause 10 of EN 681-1:1996.

- The nominal size
- Manufacturers identification
- The number of the BS or BSEN with seal type designation.
- Abbreviation for the elastomer

1.4 PIPE MATERIAL – DI PIPES

1.4.1 General

The pipes for domestic water supply will be centrifugally cast (spun) Ductile Iron pipes for Water and Sewage confirming to the IS 8329: 2000. The pipes used will be either with push on joints (Rubber Gasket Joints), Flanged joints. The class of pipe to be used shall be of the class K-9. The ductile iron pipes are usually provided with cement mortar lining at the factory by centrifugal process to ensure a uniform thickness throughout its length.

The ductile iron pipes have excellent properties of machinability, impact resistance, high wear and tear resistance, high tensile strength and ductility and corrosion resistance. DI pipes, having same composition of CI pipe, will have same expected life as that of CI pipes. They are strong, both inner and outer surfaces are smooth,

free from lumps, cracks, blisters, and scars. The ductile iron pipes stand up to hydraulic pressure tests as required by service regulations. These pipes are approximately 30 % lighter than conventional cast iron pipes.

The pipes will be supplied in standard length of 5.0m, 5.50 and 6.00meters length with suitably rounded or chamfered ends. Each pipe of the push on joint variety will also be supplied with a rubber EPDM gasket. Any change in the stipulated lengths will be approved by the Engineer – in charge. The gaskets will confirm to the IS 5382:1985 and IS: 12820-2004.

The specials and gaskets should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes, in case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under its own supervision and have it tested at his/sub-contractors' premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

The flanged joints will confirm to the Clause 6.2 of IS 8329-2000. The pipe supply will also include one rubber gaskets for each flange.

1.4.2 Coating

a) General

Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Buried pipes and fittings shall also have a site or factory applied polythene sleeving. Coating shall not be applied to pipe and fittings unless its surface is clean, dry and free from rust. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer.

b) Zinc Coating

Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m² as described in Clause 5.2 of ISO 8179.

c) Bitumen Coating

Bitumen coating shall be of normal thickness 75 microns unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

d) Polythene Sleeving

Where polythene sleeving is specified to be applied in addition to bitumen coating it shall comply with ISO 8180. Site applied sleeving shall be stored under cover, out of direct sunlight, and its exposure to sunlight shall be kept to a minimum. Pipes having factory applied sleeving must be stored in the same conditions. Joints in the sleeving shall be properly overlapped and taped in accordance with Manufacturer's instructions to provide in continuous sleeving.

e) Epoxy painting

Unless otherwise specified, pipes and fittings above ground level shall be epoxy painted.

All exposed pipes and fittings shall be painted externally with zinc rich epoxy primer and epoxy paint. Both shop and site application is to be done by airless spray equipment. Paints of reputed make and approved by Engineer shall be used. Thinning or heating of paints will not be permitted except with specific approval from Engineer and in accordance with manufacturer's instructions.

Each lot of primer and paint used by Contractor shall be accompanied by certified copies of the test results on hardness, impact and heat resistance and resistance to corrosion carried out by manufacturers in accordance with relevant Indian or International standards.

Surface preparation shall be in accordance with manufacturer's instructions, but as a minimum the pipes shall be abrasive blast cleaned to BS 7079 Grade Sa 2.5 or equivalent to achieve surface roughness profile of 40 – 50 microns. The primer shall be applied within 2 hours of surface preparation, before flash rusting can occur. Two coats of Zinc rich epoxy primer shall be applied by spray equipment on the pipes and fittings.

The priming coat shall be uniform in thickness and free from floods, runs, sags, drips, and bare spots. Any bare spots or defects shall be recoated with an additional gift application of the primer. All defects shall be rectified as per the instructions of the Engineer.

Though the priming coats become touch dry in 10 to 15 minutes, the finishing coats with epoxy paints shall be applied after allowing the film to cure at least for 48 hours. The final dry film thickness shall be a minimum of 300 microns. This may be achieved by applying in 2 to 4 coats.

On completion of the work, the contractor shall remove any oil stains or paint spots, leaving the pipes and fittings in a clean and acceptable condition.

f) Cement Mortar Lining

All pipes and fittings shall be internally lined with cement mortar in accordance with ISO 4179/IS:11906. Cement mortar lining shall be applied at the factory in conformance with the above-mentioned standards. No admixtures in the mortar shall be used without the approval of the Engineer.

Pipe linings shall be inspected on site and any damage or defective areas shall be made good to the satisfaction of the Engineer.

Lining shall be uniform in thickness all along the pipe. The minimum thickness of factory applied cement mortar lining shall be 3 mm for diameter upto DN 300 mm pipe; 5 mm for DN 350 to 600 mm pipe; and 6mm for DN 800 mm pipes and above.

1.4.3 Inspection and Testing

The pipes will be subjected to following tests for acceptance:

- Visual and dimensional check as per Clause 13 and 15 of IS 8329-2000
- Mechanical Test as per Clause 10 of IS 8329-2000
- Hydrostatic Test as per Clause 11 of IS 8329-2000/Clause No 8 of IS 12288-1987
- The test reports for the rubber gaskets shall be as per acceptance tests of the IS 5382-1985 and will be in accordance to Clause 3.8.
- The sampling shall be as per the provisions of the IS 8329 -2000.

1.4.4 Marking

All pipes will be marked as per Clause 18 of IS 8329-2000 and show as below:

- a) Manufacturer name/ stamp
- b) Nominal diameter
- c) Class reference
- d) A white ring line showing length of insertion at spigot end

1.4.5 Packing and Transport

The pipes should be preferably transported by road from the factory and stored as per the manufacturer specifications to protect damage transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage.

While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes for by any other approved means. Padding shall be provided between coated pipes, fittings / specials, and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to the other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible, pipes shall be unloaded on one side of the trench only. All pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for recantation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings / specials along concrete and similar pavement with hard surfaces shall be prohibited.

1.4.6 Packing for DI Specials

All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags. Nuts, bolts etc. shall be supplied in separate jute bags. Rubber rings in PE bags and nuts, bolts etc. shall be supplied in separate jute bags. The fittings should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under its own supervision and have it tested at his/sub contractor's premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

1.4.7 Specials for Ductile Iron pipes

a) General

This section covers the general requirements for Ductile Iron (DI) fittings suitable for Tyton / Flange joints to be used with Ductile Iron pipes system.

b) Types of specials

The following types of DI fittings shall be manufactured and tested in accordance with IS: 9523-2000 or BS: EN 545.

- i. Flanged socket
- ii. Flanged spigot
- iii. Double socket bends
- iv. Double socket branch flanged tee
- v. All sockets tee.
- vi. Double socket taper.
- vii. All flanged tees.

viii. All flanged taper.

c) Specials

All the DI fittings shall be supplied with one rubber ring for each socket. The rubber ring shall conform to IS: 12820-2004 and IS: 5382 -1985 as described in the preceding chapter. Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts.

1.4.8 Lubricant for Ductile Iron Pipes

a) General

This section covers the requirements for lubricant for the assembly of Ductile Iron pipes and specials.

b) Specification

The lubricant has to have the following characteristics:

- i. Must have a paste like consistency and be ready for use
- ii. Has to adhere to wet and dry surfaces of DI pipes and rubber rings.
- iii. To be applied in hot and cold weather; ambient temperature 0 - 50°C, temperature of exposed pipes up to 70°C
- iv. Must be non-toxic.
- v. Must be water soluble.
- vi. Must not affect the properties of the drinking water carried in the pipes.
- vii. Must not have an objectionable odour
- viii. Has to inhibit bacterial growth.
- ix. Must not be harmful to the skin.
- x. Must have a shelf life of not less than 2 years.
- xi. Acceptance tests shall be conducted in line with the provisions of the IS 9523-2000.

1.4.9 Specifications for Laying and Jointing of Pipeline System for Water Supply

a) Trench excavation

The trench excavation of pipeline shall be in accordance with IS 12288. Pipe trenches shall be excavated to the lines and levels shown on the drawings or as directed by the Engineer in Charge. The depth of the excavated trench shall be as given in the drawings or as directed by the Engineer in Charge. The width of the trench at bottom between the faces of sheeting shall be such as to provide 200 mm clearance on either side of the DI pipe. No pipe shall be laid in a trench until the section of trench in which the pipe is to be laid has been approved by the Engineer in Charge

b) Laying and jointing of DI pipes and fittings

Pipes should be lowered into the trench with tackle suitable for the weight of pipes. For smaller sizes, up to 200 mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes suitable mechanical equipment have to be used.

All construction debris should be cleared from the inside of the pipe either before or just after a joint is made. This is done by passing a pull-through in the pipe, or by hand, depending on the size of the pipe. All persons should vacate any section of trench into which the pipe is being lowered.

On gradients of 1:15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe should be held firmly in position while the trench is back filled over the barrel of the pipe.

The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc. Where a pipeline crosses a watercourse, the design and method of construction should take into account the characteristics of the watercourse to ascertain the nature of bed, scour levels, maximum velocities, high flood levels, seasonal variation, etc. which affect the design and laying of pipeline.

The assembly of the pipes shall be made as recommended by the pipe manufacturer and using the suitable tools.

The socket and spigot ends of the pipes shall be brushed and cleaned. The chamfered surface and the end of the spigot end have to be coated with a suitable lubricant recommended by the manufacturer of the pipes. Oil, petroleum bound oils, grease or other material which may damage the rubber gasket shall not be used as lubricant. The rubber gasket shall be inserted into the cleaned groove of the socket. It has to be checked for correct positioning.

The two pipes shall be aligned properly in the pipe trench and the spigot end shall be pushed axially into the socket either manually or with a suitable tool specially designed for the assembly of pipes and as recommended by the manufacturer. The spigot has to be inserted up to the insertion mark on the pipe spigot. After insertion, the correct position of the socket has to be tested with a feeler blade.

Deflection of the pipes -if any- shall be made only after they have been fully assembled.

The deflection shall not exceed 75 % of the values indicated by the pipe manufacturer.

c) Hydrostatic Testing of DI Piping at Site

The completed pipeline may be tested either in one length or in sections: the length of section depending upon:

- i. availability of suitable water,
- ii. number of joints to be inspected, and
- iii. difference in elevation between one part of the pipeline and another.

It is prudent to begin testing in comparatively short length of test section. Progressively as experience is gained, lengths of about 1.5 km or more, are tested in one section, subject to consideration of length of trench which can be left open in particular circumstances.

Each section should be properly sealed off, preferably with special stop ends secured by adequate temporary anchors. The thrust on the stop ends should be calculated and the anchors designed to resist it. All permanent anchors should be in position and, if concrete, should have developed adequate strength before testing begins. The section under test should be filled with water, taking care that all the air is displaced either through vents at the high points or by using a pig or a sphere.

The test pressure to be applied should be not less than 1.5 times X design pressure.

After filling, the pipeline should be pressurized to the specified operating pressure and left for a period of time to achieve stable conditions.

The length of this period of time depends on many factors such as slight movement of the pipeline under pressure, whether air is trapped in the pipeline or whether the pipeline has a concrete lining which absorbs water.

The pipeline is then pressurized up to the full test pressure and the section under the test completely closed off. The test should be maintained for a period of not less than 10 minutes to reveal any defects in the pipes, joints or anchorages.

The test pressure should be measured at the lowest point of the section under test or alternatively, an allowance should be made for the static head between the lowest point and the point of measurement, to ensure that the required test pressure is not exceeded at the lowest point.

1.4.10 Pillars for ductile iron pipes

In case of unstable subsoil or in case of ductile iron pipes laid above ground they shall be laid on pillars. Each pipe is supported at the plain end and behind the socket. One pillar shall support the socket end of one and the plain end of the other pipe. The pillars shall be of Cement Concrete and shall be founded on solid soil, not subject

to erosion by wind or water. The foundation of the pillars has to be calculated according to the soil conditions.

The top of the pillar shall form two saddles for the pipe having the same radius as the pipe. The socket will be lying free between the two saddles. The pipes shall be laid on a coat of polyethylene of 2 mm thickness, put on mortar. It has to be ensured that the spigot end of the pipe is supported by the saddle and does not unduly compress the rubber ring in the lower part. Each pipe is fixed by one adjustable galvanized steel spanner, fixed to the pillar with anchor bolts.

In case of vertical deviations, the pipes shall be protected against uplift by additional reinforced clamps of mild steel. In this case, the design of the pillar has to be made taking in account these uplift forces and design will be given by Engineer.

1.4.11 Thrust Block

The thrust blocks shall be of plain/reinforced cement concrete on site as per design and drawings to be given by ENGINEER-IN-CHARGE. The thrust blocks shall be cast directly against the undisturbed soil.

1.4.12 Supply of Ductile Iron Pipes

The Contractor will have to supply D.I. pipes manufactured by manufacturer who has been in business of supply of D.I. pipes rubber ring jointed and have proven record of successful supply and testing of pipeline.

1.4.13 Polyethylene Encasement

Polyethylene sleeving shall confirm to ISO: 8180

Thickness: Low density polyethylene film shall have a nominal thickness of 0.008 in, (8 mil or 200mm). The minus thickness tolerance on thickness is 10% of the nominal thickness.

Material and wrapping of polyethylene coating shall be as per standard of ANSI/AWWA C105/A21.5.

1.4.14 Measurement

All pipes shall be measured according to the work actually done and no allowance will be made for any waste in cutting to the exact length required. Pipes and fittings shall be described by their internal diameter and length measured in running meters. The measurement shall be taken along the centre line of pipe excluding fittings which

shall be measured separately. The lengths of pipes shall not include the portion of spigots within the sockets of fittings and pipes.

The rate for providing, laying and jointing of DI pipes and fittings shall be deemed to include the cost of jointing material and testing at work site.

1.4.15 Notes

If any damage is caused to the pipeline during the execution of work or while cleaning /testing the pipeline as specified, Contractor shall be held responsible for the same and shall replace the damaged pipeline and retest the same at his own cost of the full satisfaction of Engineer.

Water for testing of pipeline shall be arranged by Contractor at his own cost.

Water Supply Appurtenances

The water supply system (transmission and distribution system) shall be provided with the following appurtenances and specials etc as per the criteria given below:

- a. The mains shall be provided with sluice valves. The size of the valve shall be the same as pipe dia.
- b. The scour valves shall be provided at low points or at natural drainage for emptying the pipe when necessary. The drainage arrangement will consist of a special having drain pipe at the bottom and a sluice valve connecting to the nearby drain. The size of the drain valve will be as per CPHEEO guidelines.
- c. The pipeline shall be provided with air valves at every summit point and also at about 1 Km distance, suitably. The size of the air valve will be as per CPHEEO guidelines.
- d. All the valves shall be enclosed in valve chambers with manhole cover and frames as per relevant standard and codes.
- e. At bends and gaps suitable specials shall be provided. The use of specials shall be kept to the minimum possible.
- f. Concrete anchor in M20 concrete will be provided at bends and below valves to avoid movement of pipe as per the standard.

- g. At crossing of roads, concrete encasing with re-filling and compaction along with necessary WBM and bitumen layers shall be provided.
- h. The above information is for guidance of the bidder. It is Contractor's responsibility to complete the work in all respect. Any additional work, if required, to complete the work shall be done by the contractor at no extra cost and the same shall be deemed to be included in his Price Bid. Such additional work shall be as per design criteria and specifications as mentioned in the Tender document and as approved by the Employer.

1.5 Valves

To isolate and drainpipe sections for test, installation, cleaning and repairs, a number of appurtenances or auxiliaries are generally installed in the line.

1.5.1 Sluice Valve

Sluice valves or gate valves are the normal type of valves used for isolating or scouring. They seal well under high pressures and when fully open, offer little resistance to fluid flow. There are two types of spindles for raising the gate; a rising spindle which is attached to the gate and does not rotate with the hand wheel, and a non-rising spindle which is rotated in a screwed attachment in the gate. The rising spindle is easy to lubricate.

The gate may be parallel sided or wedge shaped. The wedge gate seals best but may be damaged by grit. For low pressure, resilient or gunmetal scaling faces may be used for high-pressure, stainless-steel seals are preferred.

Sluice valves are not intended to be used for continuous throttling, as erosion of the seats and body cavitations may occur. If small flows are required to bypass, valve is more suitable for this duty.

Despite sluice valve's simplicity and positive action, they are sometimes troublesome to operate. They need a big force to unseat them against high unbalanced pressure and large valves take many minutes to turn open. or closed, for which power operated or manual operated actuators are also used. Some of these problems can be overcome by installing a valve with a smaller bore than the pipeline diameter.

In special situations variations of sluice valves suited to the needs are used; needle valves are preferred for fine control of flow, butterfly valves for ease of operation and cone valves for regulating the time of closure and controlling water hammer.

a) Design Requirements:

Sluice valves shall generally conform to IS 14846:2000. The body of the valve shall be designed for 1.5 times the rating of the valve. The pressure drop across valve shall be limited to 0.05 mwc. Valve flange faces shall be parallel to each other, and flange face should be at right angle to the valve centerline. The back side of valve flanges shall be machined, or spot faced for proper seating of bolt head and nut.

b) Features of Construction:

The valves shall have non-rising spindle. Valves shall have a back seating arrangement for replacement of packing without leakage. The valve shall incorporate an intermediate valve gear box connecting valve spindle to the actuator. Flanges shall be drilled as per ANSI B16.1, 150#. Valves shall be provided with shoe and channel arrangement. The gap between shoe and channel shall not exceed 1.5 mm. Valves shall be with gear arrangement so that force required on hand wheel shall be limited to 80 N (8 kg). The direction of closing the valve shall be clockwise.

c) Materials of Construction

i. Body	:	CI IS 210 Gr. FG 220
ii. Wedge	:	CI IS 210 Gr. FG 220
iii. Spindle	:	SS Conforming to BS 970, Gr. 304 S11
iv. Wedge rings	:	Bronze to IS: 318 Gr. LTB2
v. Wedge nut	:	Bronze to IS: 318 Gr. LTB2
vi. Internal Hardware	:	SS 316
vii. External Hardware	:	SS 304

d) Design parameters

i. Size (mm)	:	As per BOQ
ii. Rating (bar (g))	:	10
iii. Quantity	:	As per BOQ.

e) Testing as per IS 14846:2000:

i. Body hydrostatic test	:	15 bar (g)
ii. Seat leakage test	:	10 bar (g)
iii. Back seat pressure	:	5 bar (g)

f) The rates are inclusive of:

1. Cast Iron (CI) / Ductile Iron (DI) Sluice Valve of required type, size & pressure rating.

2. Fixing & jointing material.
3. Making all damage good to original condition after completion of installation work.
4. Testing.
5. All necessary materials, labour and use of tools

1.5.2 Scour Valve

In pressure conduits, small gate off-take known as blow-off or scour valves are provided at low points above line valves situated in the line on a slope such that each section of the line between valves can be emptied and drained completely. They discharge into natural drainage channel or empty into a sump from which water can be pumped to waste.

The exact location of scour valves is frequently influenced by opportunities to dispose of the water. Where a main crosses a stream or drainage structure, there will usually be a low point in the line, but if the main goes under the stream or drain, it cannot be completely drained into the channel. In such a situation it is better to locate a scour connection at the lowest point that will drain by gravity and provide for pumping out: the part below the drain pipeline.

There should be no direct connection to sewers or polluted watercourses except through a specially designed trap Chamber or pit. For safety, two blows off valves are placed in series. The outlet into the channel should be above the high-water line. If the outlet must be below high water, a check valve must be placed to prevent back flow.

The size depends on local circumstances especially upon the time in which a given section of line is designed to be emptied and upon the resulting velocity of flow, Calculations are based upon orifice discharge under a filling head, equal to the difference in elevation of the water surface in the conduit and the blow off less the friction head. Frequency of operation depends upon the quality of the water carried, especially on silt loads.

1.5.3 Air Valves

a) Scope

The item includes supplying of single, double action or kinetic air Valve of specified diameter as mentioned in the schedule including fixing.

b) Material

Single air valve shall have single small or large orifice for releasing air during pipe filling and ventilating the pipe during emptying. Air valves up to 50 mm diameter directly shall be screwed on the main.

Double air valve shall have two ball chambers, on outlet of large capacity shall be provided for admission and release of bulk volume of air during emptying and filling of the main, another of small outlet type for the escape of smaller quantities of air accumulating under pressure. They shall be of flanged type.

Air valve body, bonnet, glands, caps, joints support rings shall be best grey iron of selected grade, 200 of IS-210-1978 specification for grey iron castings.

Ball guides of small orifice units and outlet bushes of large orifice valves shall be of gunmetal.

Nipples, spindles shall be machined from rolled, extruded or forged high tensile brass or aluminium bronze.

The balls shall be of rubber covered and vulcanite covered. The rubber shall have a smooth and solid surface. It shall be as per I.S. 638-1965 specification for rubber and insertion jointing.

Air valve shall be provided with isolation valve with IS certification mark and isolation valve

Air valves (DAKT type) shall be of the kinetic, double orifice type, suitable for releasing or admitting air in large volume when pipe is being charged or emptied and to release accumulated air under pressure.

Air valves shall comprise of cast iron body having faced and drilled flange at inlet and with two chambers each housing a ball. One chamber shall have small orifice plate and other a large orifice plate. Balls shall be of injection molded plastic with high impact strength.

Air valves shall be provided with a separate cast iron double flanged gate valve for isolation. Both the air valve and gate valve shall be rated for 10 bar (g).

- The size of air valves shall be 50 mm.
- Air valves shall conform to IS: 14845-2000

c) Testing

The Air Valve and the joints shall be tested hydraulically to a minimum pressure of 16 kg/cm² or 1.5 times working pressure whichever is greater for minimum 4hrs without any leakage.

d) RATES

1. Supplying and fixing Air Valve of specified diameter and type with isolation valve.
2. Fixing & Jointing material & specials.
3. Painting.
4. Making all damage good to original condition after completion of installation work.
5. Testing & commissioning
6. All necessary materials, labour and use of tools.

1.5.4 Pressure Reducing Valves

a) Scope

The item includes provision of pressure reducing valve of specified diameter with all accessories as mentioned in the schedule including fixing.

b) Material and Fixing

The Pressure Reducing Valve shall maintain a constant downstream pressure regardless of changing inlet pressure. It shall provide full and accurate pressure regulating capabilities irrespective of whether it is operated electrically or manually.

Pressure reducing valves shall be spring actuated direct acting type and should be easy to install with threaded end connections. All valve components shall be accessible and serviceable without removing the valve from the pipeline.

When flow begins, the pressure on the underside of the diaphragm will be lower than the set-point of the spring causing the diaphragm to move the valve seat away from the valve seal allowing flow to occur. As the flow increases downstream, the pressure acting on the spring pushes the diaphragm and the valve seat away from the valve seal to regulate outlet pressure to desired value.

When there is no flow, the downstream pressure increases and acts against the underside of the diaphragm, pulling the valve seat up against the valve seal to close the valve.

At all times the difference between inlet and outlet pressure shall be at least 14.5 psi and maximum 150 psi, if the difference is greater than 150 psi use two valves in series.

Body and cover shall be bronze, diaphragm of NBR (Buna-N), Disc shall be of EPDM and strainer to be SS with inline mesh. Spring shall be stainless steel.

c) Rates

1. Pressure reducing valve set/assembly having pressure reducing valves of specified diameter, isolating valves & pressure gauges on inlet & outlet, strainer at inlet & pressure relief valve on outlet including fixing.
2. Fixing & jointing material.
3. Painting.
4. Making all damage good to original condition after completion of installation work.
5. Testing & commissioning.
6. All necessary materials, labour and use of tools.

1.5.5 VALVE CHAMBERS

Valve chambers shall be constructed according to the typical drawings suitable for the respective valve and special arrangement if any shall be approved by ENGINEER-IN-CHARGE. They shall be constructed in Reinforced Cement Concrete. The top slab cover shall be Fiber Reinforced Polymer (FRP) Covers (FRP Covers) as per specification of BS EN 124. The chambers shall be constructed after the laying of the pipes and the assembly of specials and valves. The work shall include excavation, consolidation, levelling, lean concrete as per drawing in foundations, finishing, refilling. It shall include all labour and material required for the complete chamber. All the chambers for valves will be constructed as per the direction of ENGINEER-IN-CHARGE.

1.5.6 Technical Datasheets - Mechanical

The Bidder shall furnish the following details as a part of the technical bid for each equipment. The Bidder shall furnish all relevant catalogues pertaining to the equipment.

A) Sluice Valves

Sr. No	Description	Unit	Particular
1.0	General		
1.1	Make	-	

Sr. No	Description	Unit	Particular
1.2	Valve size	mm	
1.3	Quantity	Nos	
1.4	Applicable standard	-	
1.5	Valve rating	-	
1.6	Spindle	-	
1.7	Installation condition	-	
1.8	Hand wheel	-	
1.9	Companion flanges	-	
1.10	Spindle cap	-	
1.11	Extended spindle and floor stand	-	
1.12	Bypass arrangement	-	
1.13	Locking arrangement for hand wheel	-	
1.14	Valve gate position indicator	-	
2.0	Technical particulars		
2.1	Fluid medium	-	
2.2	Fluid temperature(design)	°C	
2.3	Flange drilling standard	-	
2.4	Direction of rotation of hand wheel for closing	-	
2.5	Differential pressure across valve during opening and closing	-	
2.6	Time for full open to full close	secs	

Sr. No	Description	Unit	Particular
2.7	Torque at hand wheel (in case of handwheel operated valve)	Kg-m	
2.8	Weight of valve with accessories	Kg	
3.0	Materials of construction		
3.1	Body, bonnet, Dome, stuffing box, gland, thrust plate, and cap, gear box cover and casing.	-	
3.2	Wedge	-	
3.3	Seat, Face ring	-	
3.4	Spindle / Stem	-	
3.5	Bonnet Gasket	-	
3.6	Internal Fasteners	-	
3.7	Externals nuts, bolts & washers	-	
3.8	Handwheel	-	
3.9	Spur gear	-	
3.10	Pinion with shaft.	-	
3.11	Wedge nut, channel and shoe sections.	-	
4.0	Test and inspection		
4.1	Body hydrostatic test pressure	Bar	
4.2	Seat leak test pressure	Bar	

B) Butterfly Valves

Sr. No	Description	Unit	Particulars
1.0	General		
1.1	Make	-	
1.2	Valve size	mm	
1.3	Quantity	Nos	
1.4	Valve location	-	
1.5	Applicable standard	-	
1.6	Valve rating	MPa	
1.7	Body type	-	
1.8	Type of valve operator	-	
2.0	Technical particulars		
2.1	Fluid medium	-	
2.2	Fluid temperature(design)	°C	
2.3	Flange drilling standard	-	
2.4	Direction of rotation of hand wheel for closing	-	
2.5	Maximum Differential pressure	kPa	
2.6	Valve flange face	-	
2.7	Drilling standard	-	
2.8	Preferred face to face dimension	-	
2.9	Power supply	Phase,V, hz,	
2.10	Valve opening / closing time	secs	
2.11	Fail safe position of actuator	-	
2.12	CV value	-	

Sr. No	Description	Unit	Particulars
2.13	Valve operating torque	N-m	
2.14	Weight of valve with accessories	Kg	
2.15	Provision of accessories	-	
2.16	Disc	-	
2.17	Companion flanges	-	
2.18	Actuator type	-	
2.19	Locking arrangement for hand wheel	-	
2.20	Valve gate position indicator	-	
2.21	Valve shaft orientation	-	
2.22	Electric actuator		
2.23	Type	-	
2.24	Make, model	-	
2.25	Motor rating	-	
2.26	Output torque	N-m	
3.0	Materials of construction		
3.1	Body & Disc	-	
3.2	End covering	-	
3.3	Shaft	-	
3.4	Bearing	-	
3.5	Thrust pad	-	
3.6	Valve seal	-	

Sr. No	Description	Unit	Particulars
3.7	Seat ring	-	
3.8	Gland plate / End cover	-	
3.9	Clamping ring / segments	-	
3.10	Gland seal & 'O' rings	-	
3.11	Internal & External Fasteners	-	
3.12	Hand wheel	-	
3.13	Internal coating	-	
3.14	External coating	-	
4.0	Accessories		
4.1	Floor stand	-	
4.2	Companion flange with bolts, nuts & gaskets	-	
4.3	Lifting lugs	-	
4.4	Tapped holes in lug	-	
4.5	Extension spindle	-	
4.6	Torque & limit switch mechanism	-	
4.7	End limit switches	-	
4.8	Adjustable seat	-	
4.9	Reduction gear unit	-	
4.10	Locking device	-	
4.11	Valve position indicator	-	
4.12	Body lining	-	

Sr. No	Description	Unit	Particulars
4.13	Auxilliary hand wheel	-	
4.14	Blow out proof stem	-	
5.0	Spares		
5.1	Disc seal rings	-	
5.2	Flange gasket	-	
5.3	Seat/seal clamping bolts	-	
5.4	'O' ring seals or gland packing	-	
6.0	Tests and inspection		
6.1	Hydrostatic test pressure for body	Bar	
6.2	Hydrostatic test pressure for seat	Bar	
6.3	Disc strength test pressure	Bar	
6.4	Actuator performance test pressure	Bar	
6.4	Air leak test pressure	Bar	

C) Air Release Valves

Sr. No	Description	Units	Particulars
1.0	General		
1.1	Type	-	
1.2	Size	mm	
1.3	Quantity	Nos	
1.4	Make	-	
1.5	Model	-	

Sr. No	Description	Units	Particulars
1.6	Pressure Rating	-	
1.7	Design Standard	-	
2.0	Material of Construction		
2.1	Valve Body, orifice chamber cover & cowl	-	
2.2	Small orifice floats	-	
2.3	Large orifice floats	-	
2.4	Large orifice	-	
2.5	Small orifice plug	-	
2.6	Large orifice seat ring	-	
2.7	Guides for small orifice float	-	
2.8	Joint Ring	-	
2.9	Fasteners	-	
3.0	Flange	-	

1.6 Instrumentation and Control

1.6.1 Electromagnetic Water Meter

a) General

Water meter shall be BMS compatible with RS 485 port. Water meters of approved make and design shall be supplied for installation at locations as shown. The water meters shall meet with the approval of local supply authorities. Suitable valves and chambers or wall meter box to house the meters shall also be provided along with the meters.

The meters shall conform to Indian Standard IS: 779 and IS: 2373. Calibration certificate shall be obtained and submitted for each water meter.

Provision shall also be made to lock the water meter. The provision shall be such that the lock is conveniently operated from the top. Where the provision is designed for use in conjunction with padlocks, the hole provided for padlocks shall be a diameter not less than 4mm.

(Note: The water meters to be installed and at every use of water such as Landscape irrigation, Domestic, Drinking Flushing, Rainwater, HVAC soft etc.).

b) INSTALLATION OF WATER METERS AND STOP COCK

The G.I. lines shall be cut to the required lengths at the position where the meter and stop cock are required to be fixed. Suitable fittings shall be attached to the pipes. The meter and stop cock shall be fixed in a position by means of connecting pipes, jam nut and socket etc. The stop cock shall be fixed near the inlet of the water meter. The paper disc inserted in the ripples of the meter shall be removed. And the meter installed exactly horizontal or vertical in the flow line in the direction shown by the arrow cast on the body of the meter. Care shall be taken that the factory seal of the meter is not disturbed. Wherever the meter shall be fixed to a newly fitted pipeline, the pipeline shall have to be completely washed before fitting the meter.

c) TESTING

- All pipes, fittings and valves shall be tested in accordance with IS: 2065 except as may be modified herein under. All pipes, fittings and valves, after fixing at site, shall be tested to a hydrostatic pressure of 1.5 times the shut off head of the pump.
- The test pressure shall be maintained for a period of at least thirty minutes without any drop in pressure.
- A test register shall be maintained, and all entries shall be signed and dated by the Contractor(s) and the Engineer.
- For water meter size contractor to refer drawings

d) RATES

1. Water meter with electronic sensor.
2. Electronic Sensor with BAS connectivity.
3. Making flanged joints with nuts & bolts.
4. Making all damage good to original condition after completion of installation work.
5. Testing the entire system and rectification of defects if any.
6. All necessary materials, labour and use of tools.

1.6.2 Technical Datasheets**A) Electronic Flow Meter**

1.	1.0 <u>GENERAL</u>	
2.	Manufacturer:	*
3.	Model no.:	*
4.	Quantity:	**
5.	Tag no	**
6.	Area classification: ZONE 0 ☐ 1 ☐ 2 ☐ ; GROUP IIA ☐ IIB ☐ IIC ☐ ; TEMP. CLASS T1 ☐ T2 ☐ T3 ☐ T4 ☐ T5 ☐ T6 ☐	x
7.	Weather protection class: IP 65 ☒ IP 66 ☐	✓
8.	Ex-Proof: Exd ☐	✓
9.	SIL Level (Note-7): Required as minimum SIL-__ as per IEC 61508 & IEC 61511 Required ☐ Not Required ☐	
10.	Accuracy: Better than +/- 0.5% of flow rate	✓
11.	Repeatability: ±0.25% of reading	✓
12.	Automatic zero provision	✓
13.	Online electrode cleaning arrangement: Refer Note- 6	✓
14.	Maximum permissible cable distance between flow tube and transmitter: 5 Meter ☒	✓
15.	Empty tube detection: Required ☒	✓
16.	Rangeability:	*
17.	2.0 <u>PROCESS DATA</u>	**
18.	3.0 <u>FLOW TUBE</u>	

19.	Process connection: Flanged	✓
20.	Electrical connections: ½" NPTF	✓
21.	4.0 <u>Electrode type: EMF Meter</u> ☒	✓
22.	5.0 <u>Liner: Required</u> ☒	
23.	6.0 <u>Grounding type: Grounding Ring</u> ☒ <u>Grounding Electrode</u> ☐	✓
24.	7.0 <u>Coil insulation: Class F suitable for high temperature as per IEC60085 / IS 1271</u>	✓
25.	8.0 <u>MATERIAL OF CONSTRUCTION</u>	
26.	9.0 <u>Metering tube: SS316</u>	✓
27.	10.0 <u>Liner: Teflon</u> ☐ <u>PTFE</u> ☐ <u>PFA</u> ☐ <u>Hard Rubber</u> ☒	✓
28.	11.0 <u>Electrodes:</u>	**
29.	12.0 <u>Flanges:</u>	**
30.	13.0 <u>Coil housing: Di Cast Al</u> ☒	✓
31.	14.0 <u>Jacket: Required</u> ☒ <u>Not Required</u> ☐	✓
32.	15.0 <u>Converter/ electronic housing: Di Cast Al</u>	✓
33.	16.0 <u>FLOW TRANSMITTER</u>	
34.	Mounting: Integral ☒ Separate ☐	✓
35.	Type of transmitter: 4 Wire ☒	✓

36.	Display on transmitter: Flow Rate ☒ Flow Totalizer ☒	✓
37.	Type of display: LED ☐ Backlit LCD ☒ LCD ☐	✓
38.	Battery backup for flow tantalizer: Required ☐	✓
39.	Power supply: Power Supply (four wired) : 24V DC ☒ Power Supply (for wireless) : Easy to replace Lithium batteries (Note – 10) ☐	✓
40.	Output signal: 4-20mA HART ☒ Fieldbus ☐ Profibus PA ☐ Wireless ☐	✓
41.	Alarms: Hi ☐ Low ☐	x
42.	No. and type of contacts: 1 No SPDT ☐ 1 No DPDT ☐	x
43.	Contact rating: 2A@24VDC ☐	
44.	17.0 Material of housing: Di Cast Al ☒	✓
45.	Maximum load: >500 Ohms	✓
46.	Cable entry: ½" NPT (4 Nos) with Double compression cable gland	✓
47.	Diagnostic information:	✓
48.	Reverse flow:	✓
49.	Transmitter fault:	✓
50.	Coil circuit fault:	✓
51.	Ground/wiring fault (applicable for slurry application)	✓

52.	High process noise (applicable for slurry application)	✓
53.	18.0 <u>WIRELESS</u> <u>TRANSMITTER</u>	x
54.	Transmitter update rate: Selectable between 4 sec to 60 sec	
55.	Battery Voltage and Drain time:	x
56.	Battery life: Min. 2yrs with 4 sec. update rate or better (Note-8)	x
57.	Antenna type: Integrated Omni directional Antenna ☐ Remote mount Omni directional Antenna ☐	x
58.	Signal Range: Minimum 200m or better without any repeater & with clear line of sight	x
59.	Wireless Frequency: 2.4GHz license free ISM Band	x
60.	Radio security: AES 128-bit encryption	x
61.	Wireless Protocol: ISA 100.11a (IEC 62734) / Wireless HART (IEC62591-1)	x
62.	Transmitter Configuration: via gateway over wireless network	x

63.	Device programming: Transmitter to work as input device, repeater and Access point	x
64.	Network: Note-9	x
65.	<u>ACCESSORIES</u>	
66.	Spool piece for start-up use	✓
67.	Matching flanges, nuts and bolts	✓
68.	Name plate/ metal tag	✓
69.	Cable between flow tube and transmitter unit: Required ☒ Not Required ☐	
70.	Remote flow indicator & integrator: Required ☒ Not Required ☐	
71.	Mounting brackets: Required ☒ Not Required ☐	
72.	<u>CODES AND STANDARDS</u>	

73.	Test and calibration: IEC 17025	✓
74.	Ex-Proof protection: IEC 60079	✓
75.	Weather protection class: IEC 60529	✓
76.	EMC requirement: IEC 61326-1	✓
77.	Shock & vibration Resistance: IEC 60068-2-6	✓
78.	<u>TESTS</u>	
79.	Calibration test certificate: 5 Points Calibration ☒	✓
80.	Hydrostatic:	✓
81.	Test certificate from CMRI / ERTL for equipment manufactured in India	✓
82.	Certificate of conformity from LCIE, BASEEFA, PTB, CSA, UL, ATEX for equipment manufactured outside India	✓

Notes:

- (*) - Bidder to furnish details; (✓) - Required; (x) - Not required / Not applicable.
- The bidder shall indicate all applicable codes and standards.
- The velocity limits to be considered for meter sizing shall be as mentioned below.
 - For slurries and viscous flow: 4 to 5 m/s
 - For all other service: 2 to 3 m/s
 Velocities beyond these limits shall not be considered.
- Field bus-based transmitter shall meet following requirement.

- a) All instruments must satisfy the requirement of field bus registration laboratory with applicable check marks like foundation field bus, Profibus PA or as specified.
 - b) All instruments shall have two analog input blocks as minimum. in addition, when specified the transmitter shall also have PID controller block.
 - c) All instruments must be interoperable and shall have valid interoperability test clearance like ITK 4.6 for foundation field or equivalent for PA as applicable.
 - d) The field bus instrument shall support peer to peer communication.
 - e) Field bus instrument offered shall not be polarity sensitive.
5. The configuration data for the instrument shall be stored in non-volatile memory.
 6. Whenever process fluid has coating characteristics, where cleaning of electrode is necessary because of coating, vendor shall offer online removable electrode.
 7. TUV / EXIDA certification as per IEC 61508 & IEC 61511 for SIL rated flow transmitters shall be provided by vendor. Vendor to provide safety manual as per IEC 61508 for all the applicable tags which shall contains at least.
 - a) SIL rating, HFT value, Device Type, Mode of operation
 - b) Safety parameters: β , β_D , λ_{DU} , λ_{DD} , λ_{SU} , λ_{SD} , PTR, MTBF, MTTR, DC, PFD, SFF, RRF
 - c) Possible design / architectural constraints
 8. All the transmitters supplied for wireless network shall come with same type of batteries so that spare maintenance could be easier (These batteries should be compatible for all the models of Pressure, Temperature, Adaptor supplied in this network) Transmitter shall be supplied with battery removed during shipping.
 9. Wireless connectivity and all devices shall be pre-configured / field configurable with Mesh / Star / combination of both topologies with all devices configured as Transmitter, repeater based on application requirement.
 10. Adapter is required for converting an existing wired transmitter to wireless complying with IEEE 802.154.

Self-diagnostics features such as Sensor Failure, amplifier failure, configuration error, battery alarm, and wireless communication alarm and over-range error for process variables.

TECHNICAL SPECIFICATIONS FOR SEWERAGE WORKS

Table of Contents

1.0 General Work.....	3
2.0 Sewerage System	3
3.0 Scope.....	4
3.1 General Specifications for Pipe	4
3.2 Pipeline Construction.....	6
3.3 Carting & Handling	8
3.4 Storage	8
3.5 Laying	8
3.6 Reinstatement of Road/Footpath.....	11
3.7 Clearing of Site	11
3.8 Bedding	11
3.9 Compaction	13
4.0 DWC PE Pipes Specifications	14
4.1 Scope.....	14
4.2 General	14
4.3 Standards.....	14
4.4 Materials.....	15
4.5 Testing and Material Composition:	15
4.6 Designations and Dimensions of Pipes & Fittings:.....	15
4.7 Transportation:	15
4.8 Construction Methods:.....	15
4.9 Measurement- Pipes	17
5.0 Sewer Appurtenances	17
5.1 Manholes.....	17
5.2 Measurement - Manholes.....	19

TECHNICAL SPECIFICATION – SEWERAGE SYSTEM**SCOPE OF WORK**

TIDEL Park Ltd., (TIDEL) intends to establish TIDEL Park at Madurai in Thallakulam Village, Madurai North Taluk, Madurai Dist. (adjacent to Mattuthavani Bus Stand). This TIDEL Park is envisaged to be a world class IT Park with State of the Art, amenities and facilities to attract good clients to IT Park. This tender documents present the Scope of Work for proposed sewerage system for TIDEL Park, Madurai. This includes but is not limited to the following in relation to the supply, construction, testing, commissioning and five years O&M of constructed sewerage system of the Works:

1.0 General Work

- a) All preliminary works such as site clearance in all types of conditions, marking of alignment etc. as described elsewhere in these specifications, for such work no extra payment shall be made to the Contractor.
- b) Preparatory works such as confirmatory surveys if contractor so desires including its approval.
- c) Cutting of roads after proper approval and making them good.
- d) Excavation, dewatering, ramming, refilling, and disposal of surplus excavated soil for pipe trench.
- e) Sectional hydrostatic testing of complete pipeline network.
- f) Commissioning and disinfection of complete pipeline network.
- g) Removal of defects in pipeline network and allied civil, mechanical and instrumentation works after inspection and/or testing.
- h) Submission of shop drawings/ fabrication drawings for review and approval of the PMC/Project Engineer for sewage collection network before starting the execution of works at site.
- i) Providing training the staff (offsite and onsite) for operation and maintenance of sewage collection system.
- j) Repairs of all works as necessary during Defect Liability Period.
- k) Compliance with SHE norms as per requirement.
- l) To take all safeguards to avoid accident at site, prevent loss to other pipelines, telephone and electric cables and other property during all phases of working.
- m) Five-year Operation & Maintenance for sewage collection network and handing over activities on completion of project.
- n) All required spares and accessories shall be provided by Contractor till the project completion stage.
- o) Fabrication drawings for all Structural steel works are to be prepared along with design calculations and submitted for review and approval of Consultant.
- p) Submission of As-built drawings and O&M Manual.

2.0 Sewerage System

- a) Suitable flushing arrangement to maintain required velocity as recommended in CPHEEO manual to avoid deposition of solids in pipes wherever required.
- b) Construction of all type manholes as per specifications and drawings.
- c) Supply, safe storage and handling, lowering, laying jointing, testing and commissioning of DWC pipeline for sewerage system as per layout drawing.
- d) Supply, laying of pipe bedding as per specification and drawing.
- e) Preparation and Submission of As-Built drawings (GA, Plans, Sections & L-sections, etc.) for all Civil Works
- f) Testing and commissioning of the entire work.
- g) Sectional leak testing of sewers and manholes
- h) Removal of defects in laying and jointing of all sewers, fittings and manholes, after testing and during operation & maintenance period.

3.0 Scope

This specification covers the general requirements of pipes and other allied works such as manholes and ancillary works.

3.1 General Specifications for Pipe

3.1.1 Shipment and Storage

Protection of Pipes and Fittings for Shipment

Approved slings shall be used, and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the pipes properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Pipe handling equipment shall be maintained in good condition and any equipment which in the opinion of the PMC/Project Engineer may cause damage to the pipes shall be discarded.

Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

Pipes and fittings /specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the PMC/Project Engineer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible, pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

Storage of Pipes & Fittings

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500 mm diameter or

over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the PMC/Project Engineer and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape, or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m.

Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings, wherever used, shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

Transportation & Handling of Pipes & Fittings

Method statements shall be submitted by the Contractor for the approval of the PMC/Project Engineer before the handling, transportation and laying of any pipes commences. All pipes shall be handled and stored in compliance with the manufacturer's recommendations. Pipes and fittings /specials shall be transported from the factory to the central pipe store and unloaded there before being transported to Site. At every point of loading or unloading, all pipes and fittings shall be lifted using approved lifting tackle. Unloading by rolling down any form of inclined ramp will not be permitted. Pliable straps or slings shall be used to lift pipes. Rope, wire rope, hooks or chains shall not be allowed to come into contact with any pipe surface. All pipes shall be thoroughly inspected on arrival on site and immediately prior to installation. Any damage to the pipes shall be notified to the PMC/Project Engineer for a decision as to the acceptability of the pipes, with or without repairs or remedial work. The final judgement will be taken by the PMC/Project Engineer based on his judgement of the suitability of the items for the purpose intended.

3.1.2 Inspection of Pipes and Fittings

Before incorporating into the Works, each pipe shall be brushed out and carefully examined for soundness. Damaged pipes which in the opinion of the PMC/Project Engineer cannot be satisfactorily repaired shall be rejected and removed from Site.

Damage to pipe coatings or linings shall be repaired to the satisfaction of the PMC/Project Engineer.

As soon as the pipeline has been completed from manhole to manhole, the Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75mm less in diameter than the internal diameter of pipes.

If as a result of the removal of any obstructions, the PMC/Project Engineer considers that damages may have been caused to the pipelines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall make good the pipeline and carry out such further tests as ordered by the PMC/Project Engineer.

3.1.3 Marking of Pipes

Each straight length of pipe shall be clearly marked in indelible ink / paint on either end with the following information:

- a) Manufacturer's Name / Registered Trademark
- b) Internal Diameter of Pipe
- c) Class of Pipe
- d) Date of Manufacture
- e) Lot Number / Batch Number
- f) BIS Certification Marking

3.2 Pipeline Construction

3.2.1 General

Pipes shall be laid and jointed in accordance with all relevant recommendations of the manufacturer. Any variations between the manufacturer's recommendations and this Specification shall be highlighted in the Contractor's Method Statements and a ruling will be given with the approval. All pipe laying shall be performed by experienced and competent pipe layers.

The line of the pipe shall be set out and agreed with the PMC/Project Engineer well in advance of the excavation. Surface stripping, excavation, pipe laying, backfilling and reinstatement shall follow each other without undue delay or interval between these activities.

3.2.2 Laying of Pipes

i. Boning Staves and Sight Rails

In laying the pipes and fittings/ specials, the centre for each manhole / chamber or pipeline shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 x 100 x 1800 mm) at each manhole/chamber or junction of pipelines at nearly equal distance from the peg and at sufficient distances there from to be well clear of all intended excavation, so arranged that a sight rail when fixed at a certain level against the post shall cross the centre line of the manhole/chamber or pipe lines. The sight rail shall not in any case be more than 30 m apart; intermediate rails shall be put up if directed by PMC/Project Engineer.

Boning staves of 75 mm x 50 mm size shall be prepared by Contractor in various lengths, each length being of a certain whole number of metres and with a fixed tee head and fixed intermediate cross pieces, each about 300 mm long. The top-edge of the cross piece must be fixed below the top-edge of the tee-head at a distance equal to the outside diameter of the pipe or the thickness of the concrete bed to be laid as the case may be. The top of cross pieces shall indicate different levels such as excavation for pipe line, top of concrete bed, top of the pipe etc. as the case may be.

The sight rail of size 250 mm x 40 mm shall be screwed with the top edge resting against the level marks. The centre line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the centre lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe, and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of sight from rail to rail.

The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee-heads and cross-piece of the boning staves shall be painted black.

For the pipes converging to a manhole/chamber at various levels, there shall be a rail fixed for every different level. When a rail comes within 0.60 M of the surface of the ground, a higher sight-rail shall be fixed for use with the rail over the next point.

The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid, and PMC/Project Engineer gives permission to proceed with the backfilling.

ii. Laying of Pipes and Fittings/Specials

All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure/pipeline of water, gas, sewage etc. After excavation of trenches, pipes shall not be lowered unless the dimensions of trenches and bedding work for pipes at the bottom of the trenches are approved and measured by Employer /PMC/Project Engineer. Pipes and fittings/specials shall be carefully lowered in the trenches. Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings/specials shall be made by Contractor. In no case pipes and fittings/specials shall be dropped. Slings of canvas or equally non-abrasive material of suitable width or special attachment to fit the ends of pipes and fittings/specials shall be used to lift and lower the coated pipes and fittings/specials. The pipes and fittings /specials shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. If doubt persists, further confirmation shall be done by pouring a little kerosene/dye on the inside of the pipe at the suspected spot. No sign of kerosene/dye should appear on the outside surface. Pipes and fittings / specials damaged during lowering or aligning shall be rejected by the PMC/Project Engineer

All the pipes are to be laid perfectly true both in alignment and to gradient specified. In case of spigot and socket pipe the socket end of the pipe shall face upstream, except when the pipeline runs uphill in which case the socket ends should face the upgrade. The laying of pipes shall always proceed upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket. Pipes and fittings/specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings/specials of proper dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the PMC/Project Engineer. During the period that the plug is on, the Contractor shall take proper precautions against floating of the pipe owing to entry of water into the trench. Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted the deflection allowed at joints shall not exceed $2\frac{1}{2}\%$. The pipes shall be laid such that the marking on pipes appears at the top of the pipes.

The cutting of pipe for inserting valves, fittings, or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

The joints and interiors of all pipes and fittings shall be carefully cleaned before installation. Whenever pipe laying is interrupted for any reason, the open end of the pipeline shall be sealed with a suitable expanding stopper or a properly fitted temporary wooden stopper

and exposed pipes shall be suitably protected from stones and other objects falling into the trench from above.

The permissible tolerance for pipelines in trenches shall be 6mm in level and 25mm in line between manholes. After the laying of a length of a pipeline but before testing the crown of the pipe shall be checked for level and alignment and any necessary adjustment made by unjointing and removing the pipes concerned, adjusting the bedding, relaying the pipes and rechecking for line and level. In addition, where a gravity pipeline is shown on the Drawings as being straight between manholes it will not be accepted unless a light can be sighted directly through the length concerned.

While installing the pipe in trenches, the bed of the trench should be level and free from sharp edges stones. While laying in rocky areas, suitable bed of sand or gravel should be provided. The initial backfill to about 10 to 15 cm above the pipe should be fine sand or screened excavated material. Where hard rock is met with, bed concrete M-100, 15 cm thick may be provided, before putting in the soft sand / gravel.

For pipeline jointing systems incorporating flexible jointing rings, pipes shall be laid with the spigot end pointing in the direction of flow and with a gap between the end of the spigot and the base of the socket, or between spigots. Rubber rings shall comply to IS: 5382.

3.3 Carting & Handling

Pipes and fittings /specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the PMC/Project Engineer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible, pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

3.4 Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape, or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m. Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

3.5 Laying

3.5.1 Excavation

Before excavating the trench, the alignment of pipeline shall be approved by the PMC/Project Engineer. The excavation of trenches and pits for manholes/ chambers shall be carried out in accordance with the Employer's Requirements described elsewhere and

shall be done such that it does not get far ahead of the laying operation as approved by the PMC/Project Engineer.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for the traffic to use the roadways. The relevant Indian Standards and the rules and regulations of local authorities in regard to safety provisions shall be observed.

Suitable fencing shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3 m apart and they shall not be less than 75 mm in diameter or less than 1.2 m above surface of the ground. There shall be two rails, one near the top of the post and the other about 450mm above the ground and each shall be from 50mm to 70mm in diameter and sufficiently long to run from post to post to which they shall be bound with strong rope. The method of projecting rails beyond the post and tying them together where they meet will not be allowed on any account. All along the edges of the excavation trenches a bank of earth about 1.2 m high shall be formed where required by the PMC/Project Engineer for further protection.

The road metal and also the rubble packing shall first be stripped off for the whole width of the trench/pit and separately deposited in such place or places as may be determined by the PMC/Project Engineer.

During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. The material from excavation shall be deposited on either side of the trench leaving adequate clear distance from the edges of the trench and pit, or as may be necessary to prevent the sides of the trench pit to slip or fall, or at such a distance and in such a manner as to avoid covering fire hydrants, sluice valves, manholes and covers etc. and so as to avoid abutting the wall or structure or causing inconvenience to the public and other service organizations or otherwise as the PMC/Project Engineer may direct.

Contractor shall take into account additional excavation if any as the PMC/Project Engineer may require in order locating the position of water pipes, drains, sewers etc. or any other works which may be met with, in or about the excavation of trenches/pits while considering the rates for excavation. Such service lines if met with during excavation shall be properly maintained by Contractor, by means of shoring, strutting, planking over, padding or otherwise as the PMC/Project Engineer may direct, and shall be protected by the Contractor from damage during the progress of the work. All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure /pipe line of water, gas, sewage etc.

Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than the minimum requirement. In case additional width is required it shall be provided only in the top portion from the ground level upto 300 mm above the top of pipe. If any extra width is provided in the area below this portion, Contractor shall have to provide remedial measures in the form of lime concrete or rubble masonry otherwise at the discretion and to the satisfaction of the PMC/Project Engineer. If rock is met with, it shall be removed to 15 cm below the bottom of pipes and fittings/specials and the space resulting shall be refilled with granular materials and properly consolidated. Bottom of trenches/pits shall be saturated with water well rammed wherever the PMC/Project Engineer may consider it necessary to do so.

Wherever a socket or collar of pipe or fitting/ special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand all around the socket in order to make the joint, and the grip shall be maintained clear until the joint has been approved by the PMC/Project Engineer.

When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60cm in depth and 90 cm in length shall be made at joints in order to facilitate welding.

The excess excavated material shall be carried away from site of works to a place up to a distance as directed by the PMC/Project Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic. If the instructions from PMC/Project Engineer are not implemented within seven days from the date of instructions to cart the

materials and to clear the site, the same shall be carried out by the PMC/Project Engineer and any claim or dispute shall not be entertained in this respect.

3.5.2 Dewatering

During the excavation, if subsoil water is met with Contractor shall provide necessary equipment and labourers for dewatering the trenches. The Contractor shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by the Engineer. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer/drain, the Contractor shall take necessary permission from the local authorities.

3.5.3 Special Foundation in Poor Soil

Where the bottom of the trench and subgrade is found to consist of material which is unstable to such a degree that in the opinion of the PMC/Project Engineer, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant drawings to be prepared by the Contractor and as instructed by the PMC/Project Engineer shall be constructed.

3.5.4 Wooden Shoring

Contractor shall suitably design polling boards, waling and struts to meet different soil conditions that might be encountered in excavating trenches/pits. The horizontal and vertical spacing of struts shall be such that not only the sides of trenches shall be prevented from collapse but also easy lowering of pipe in trenches shall be ensured without creating undue obstructions for the excavation of the work. Any inconvenience and/or delay that might be caused in lowering pipes in trenches as a result of adopting improper spacing of struts by Contractor shall be his sole responsibility. No part of shoring shall at any time be removed by Contractor without obtaining permission from the PMC/Project Engineer. While taking out shoring planks the hollows of any form must simultaneously be filled in with soft earth well rammed with rammers and with water.

The Engineer may order portions of shoring to be left in the trenches /pits at such places, where it is found absolutely necessary to do so to avoid any damage which may be caused to buildings, cables, gas mains, water mains, sewers etc. in close proximity of the excavation, by pulling out the shoring from the excavations. The Contractor shall not claim, on any reason whatsoever, for the shoring which may have been left in by him at his own discretion.

3.5.5 Steel Plate Shoring

Where the subsoil conditions are expected to be of a soft and unstable character in trench/pit excavation, the normal method of timbering may prove insufficient to avoid subsidence of the adjoining road surfaces and other services. In such circumstances, the Contractor will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, waling etc., as per the instructions, manner and method directed by the PMC/Project Engineer. Contractor shall supply pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Employer's Requirements.

3.5.6 Jointing

Jointing for pipes and fittings/specials shall be done in accordance with the relevant Employer's Requirements depending upon the type of pipes being used.

3.5.7 Testing and Commissioning

Testing and commissioning of pipes shall be done in accordance with the relevant Employer's Requirements.

3.5.8 Backfilling

Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. The water content of the soil shall be as near the optimum moisture content as possible. Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressure does not occur. Backfilling shall be done in layers not exceeding 30 cm. Each layer shall be consolidated by watering, ramming, care being taken to avoid damage to the pipeline. In case of the mild steel pipes/specials, the spiders provided during assembly and welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipeline to aid alignment, these timbers shall be removed before backfilling.

3.6 Reinstatement of Road/Footpath

Reinstatement of road/footpath shall be done as per the requirements of local authorities and the Employer's Requirements after completion of work.

3.7 Clearing of Site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by the PMC/Project Engineer and the construction site left clean to the satisfaction of the PMC/Project Engineer.

3.8 Bedding

The pipe bedding should be placed so as to give complete contact between the bottom of the trench and the pipe. The bedding shall be provided as per the drawing. However, the bottom face / trench bed where pipe shall be placed shall be compacted to provide a minimum compaction corresponding to 95% of maximum dry density.

The type of bedding viz. granular bedding, concrete cradle – PCC, RCC, concrete encasement, etc. for which details are given below.

3.8.1 Granular Bedding

Where pipes are laid with a granular bed or surround the appropriate bedding material shall, as soon as a section of trench has been trimmed to grade, be placed carefully over the full trench width without segregation. The material shall be spread and thoroughly compacted by approved mechanical means in successive uniform layers each not exceeding 150mm compacted thickness to produce a uniform bed to the required gradient. Where plate vibrators are used, there shall be a minimum of one pass for crushed stone and two passes for sands. Hand tamping will only be permitted where insufficient space is available to allow the use of mechanical plant. The minimum thickness of compacted granular material shall be as follows: -

- i. 150mm (minimum 100mm under sockets) for pipes not exceeding 300mm nominal diameter, except when trench is in rock.
- ii. 200mm (minimum 100mm under sockets) for pipes greater than 300mm nominal diameter, or all pipes when trench is in rock.

The pipes shall then be set evenly on the bed, great care being taken to ensure uniform support for the entire length of the pipe.

Pockets in the bedding shall be formed at each pipe joint to permit jointing to be carried out without the sleeve or socket of the pipe joint bearing on the bedding material and without bedding material entering the joint.

After the pipeline alignment and joints have been inspected and approved by the PMC/Project Engineer, the water testing of the pipeline satisfactorily completed, and, where

appropriate, the annular gap at each pipe joint sealed, each joint pocket shall be carefully filled with granular material and thoroughly compacted up to the same level as the top of the bedding. Granular bedding material of the same type shall be placed on both sides of the pipeline in successive uniform layers not exceeding 150mm thick and compacted according to one of the methods given in Table 6-1 as agreed with or directed by the PMC/Project Engineer. Care shall be taken to ensure that no cavities remain under the pipe, and that the pipes are not displaced by differential pressure from either side.

When placing and compacting surround material the Contractor shall take care not to displace or damage the pipes. The tipping of surround material from ground levels directly onto the pipes shall not be permitted.

Table showing Granular Surround - Compaction Requirements

Surround Material	Max. Layer Thickness mm	Alternative Methods (Number of Passes of Compaction Plant)		
		Hand Rammer	Vibrating Plate	100kg power Rammer*
Crushed Aggregate	150	2	1	2
Sand	75	3	2	4

** not to be used above springing level*

Unless otherwise detailed on the Drawings for pipes with a full granular surround, the granular material shall extend up to a minimum height of 300mm over the crown of the pipes. For rigid pipes unless otherwise detailed, the granular material shall extend up to the springing level of the pipe. The surround shall be completed by the careful placing of selected excavated material in layers not exceeding 150mm thick, thoroughly compacted on both sides of the pipeline to a level at least 300mm above the crown of the pipes.

For pipelines of 600mm diameter or greater the bed should be prepared ahead for approximately two pipe lengths whilst two pipes are being laid and the previous two pipes are receiving side filling. For pipelines less than 600 mm diameter the lengths of each stage shall be agreed with the PMC/Project Engineer.

If the Contractor wishes to use any other method of laying pipes in granular bedding or surround, he must submit his proposals in writing to and obtain the approval in writing from the PMC/Project Engineer well in advance of the date when he wishes to perform the work.

3.8.2 Concrete Bedding

Concreting shall be carried out in accordance with specification given in General Civil and Structural Works. Concrete shall be of grade M15 unless otherwise detailed on the Drawings.

The minimum thickness of concrete between the bottom of the pipe and the trench shall be 0.25 x nominal pipe diameter, subject to 150mm minimum, with a minimum 100mm beneath sockets.

The pipes shall be set to correct alignment as detailed below:

The Contractor may use rectangular concrete blocks (two per pipe) made of grade M15 concrete, cast at least 7 days before use, together with pairs of approved hardwood wedges of the same width as the blocks in order to align and support the pipe before concreting.

The blocks and wedges shall be of sufficient size and suitably founded on the bottom of the trench to support the pipe adequately without settlement or movement at any stage. The blocks and wedges should be placed near the end of each pipe length and should be left undisturbed during jointing of subsequent pipes and during construction, although the wedges should be removed during placing of the concrete.

Blocks may have thin tie wires cast in to assist in holding down the pipe when the concrete surround is being mechanically vibrated.

After approval of the joints and satisfactory testing of the pipeline a transverse flexible joint shall be formed by insertion of a template of compressible joint filler consisting of bitumen impregnated insulating board as per BS 1142 Part 3 or other equally compressible material shaped exactly to the pipe and full extent of the concrete cradle or surround. Unless otherwise detailed on the drawings the thickness of this flexible joint shall be a minimum of 25mm.

For spigot and socket pipes, the flexible joint in the concrete shall be aligned with the face of the socket. For sleeve type and flexible mechanical joints, the flexible joint shall be aligned with one end of the sleeve or mechanical joint. In certain cases, a flexible joint may be required at both ends of the sleeve or mechanical joint. These instances may be shown on the Drawings or ordered in writing by the PMC/Project Engineer. The concrete infill for flexible mechanical joints shall only be placed after the application of the specified protection materials to the joint. No steel reinforcement shall pass through the flexible joint.

Concrete for beddings, surrounds and joint infill shall be placed carefully and uniformly, suitable measures being adopted to ensure that the pipeline is not displaced by differential side pressure or by flotation. Concrete shall be properly compacted with particular care being taken to ensure that no cavities are left underneath the pipe.

The concrete shall provide a minimum cover to the pipe of 150mm for surrounds.

Concrete beds to pipes of all diameters and surrounds to pipes of one metre diameter or less shall be poured in a single operation. Concrete surrounds to pipes over one metre diameter shall normally be poured in two lifts, with a horizontal joint not more than 100mm below the crown of the pipe. Concrete shall be prevented from entering pipe joints.

Formwork shall be used for all vertical faces and faces sloping more steeply than 1 vertically to 2 horizontally. Side forms should not normally be required, if trench widths specified are such that the concrete bedding / surround will extend the full width of the trench.

All formwork used for forming the concrete bedding shall be removed, unless the written approval of the PMC/Project Engineer is given to leave it in place for safety or similar reasons. Where side forms have been required backfilling shall be in accordance with Part 5 to fill the voids left on removal of the formwork.

The bedding and surround shall be completed by the careful placing of selected excavated material in layers not exceeding 150mm thick, thoroughly compacted by hand on both sides of the pipeline to a level at least 300mm above the crown of the pipes. As this material is placed and compacted in the trench, the supports to the sides of the trench shall be concurrently partly withdrawn so that there are no voids or uncompacted zones.

Except where otherwise specified or instructed by the PMC/Project Engineer, no traffic load may be imposed upon the trench within 72 hours of the placing of the concrete cradle or surround.

If the Contractor wishes to use any other method of laying pipes in concrete cradle or surround, he must submit his proposals in writing to and obtain the approval in writing from the PMC/Project Engineer well in advance of the date when he wishes to perform the work.

3.9 Compaction

Vibratory methods shall be used for compaction. Compaction within distances of 15 cm to 45 cm from the pipe shall be usually done with hand tampers. The backfill material shall be compacted not less than 95% of maximum dry density.

4.0 DWC PE Pipes Specifications**4.1 Scope**

This specification covers the requirements for manufacture, testing, supplying, lowering, laying, jointing, testing, and commissioning of Double wall corrugated polyethylene (DWC PE) pipes used for the conveyance of domestic sewage.

4.2 General

DWC pipes and fittings shall comply with IS 16098. All fittings shall be socketed unless specified otherwise.

4.3 Standards

The following standards, specifications and codes are part of this specification. In all cases, the latest revision of the codes including all applicable official amendments and revisions shall be referred to. In case discrepancy between this specification and those referred to herein, this specification shall govern.

Manual for Sewage collection system	CPHEEO Manual for sewerage, sewage treatment and Drainage- MoUD, Gol
SP 7	National Building Code of India
IS 456-2000	Code of Practice for plain and reinforced concrete
IS 13920-1993	Detailing of reinforced concrete structures subjected to seismic forces
IS 1786-1985	High strength deformed steel bars and wires for concrete reinforcement
IS: 8112	Specification for 43 Grade ordinary Portland cement.
IS 226-1975	Specification for Structural steel
IS 3764-1966	Safety code of Excavation works and related Drilling Operations
IS 12592:2002	Specification for Precast RCC/ SFRC Manhole Frame & cover
IS 4111-1986 Part 1 IS 5455-1997 IS 4883-1988.	Specifications for manholes
IS 11387:1985	Requirement for high pressure jetting machine for sewer cleaning
IS11972:1987	Code of practice for safety precautions to be taken when entering a sewage system

IS:16098(Part-II)-2013	Structured-Wall Plastics Piping Systems for Non - Pressure Drainage and Sewerage — Specification

4.4 Materials

DWC pipes are proposed to carry the sewerage of the built up area. The specifications and requirements shall conform to IS: 16098-Part-II-2013. The pipes shall be of Type B i.e. smooth internal surface and rough external. The pipes shall be tested by the manufacturer and the contractor shall produce a certificate to that effect from the manufacturer. The inner and outer layer of pipes and fittings shall be coloured throughout, with outside layer should preferably be black, grey, brown or orange.

4.5 Testing and Material Composition:

The material shall be of polyethylene (PE) or polypropylene (PP) to which may be added those additives that are needed to facilitate the manufacturer. Acceptance test shall be carried out whenever a change is made in the sizes/series in order to establish the usability. The pipes shall accord with the Table 1, 2, 3 & 4 corresponding to cl. 5.1 for composition of material and loading. The pipes and fittings shall have physical characteristics conforming to the requirements given in Tables 6 & 7 and Table 8 & 9 respectively.

4.6 Designations and Dimensions of Pipes & Fittings:

Pipes and fittings will be designated on the basis of its material/structure wall construction/nominal ID (DN/ID)/nominal ring stiffness, such as DWC. The internal diameter, nominal sizes, thickness and socket length shall be as per Table 5 and cl.6.3.1. The external diameter shall conform to the clause 6.3.3. The requirement regarding the socket and spigot dimension, specified in Table 2 applies. The ring stiffness of sockets and spigots shall conform to cl.6.3.5.1. The types of fittings shall comply with cl.6.4.

4.7 Transportation:

The arrangement of loading the pipes in a telescopic manner is advised, i.e. smaller directions inserted into the next higher sizes of pipes up to a height of 2.5m in a truck. Proper care shall be addressed that the spigot/coupler end should be arranged alternatively in the corresponding layer so as to avoid the damage.

Handling:

- Pipes shall be smoothly lowered to the ground.
- Pipes and fittings should not be dragged against the ground.
- A single lift point for 450mm to 900mm diameter pipes shall be sufficient. And for diameters smaller than 450mm manual labour can be used.
- Loading boom or fork lift should not be used directly on or inside of pipe and fittings.
- Pipe storage at site: Stockpiling shall be done on a flat area and to avoid collapse wooden posts/blocks shall be used. Stacking shall not be higher than 2.50m.

4.8 Construction Methods:

4.8.1 Excavation and trench preparation:

The minimum trench width is specified as per Table 21. Excavation shall be in straight lines as much as possible and as per measurements specified in drawings. The sides of the trench shall be supported by shoring (wherever necessary) to ensure proper and speedy excavations. In the event of persistence of groundwater, a well point system may be adopted to lower it. The excavation shall be filled and compacted. The minimum cover

required to prevent floatation shall comply with Table 22. The bedding works are required for the maintenance of slope with initial backfill envelope with sand or gravel over a single BFS would be sufficient.

4.8.2 Laying:

For shallow trenches place the pipe manually on the initial backfill envelope directly. For deep trenches with shoring/mild steel sheet piling:

- Make the trench free from groundwater and other liquids.
- Place the pipe on the top-level cross-struts of the timber shoring/mild steel piling frame work.
- Dismantle one/two cross struts and lower the pipe to the immediate lower layer of the cross-struts and re-fix the struts immediately.
- In the same manner, reach up to the initial back filling and place the pipe at proper slope.
- Ensure anchorage, if any, after laying.

4.8.3 Jointing:

Various methods for jointing such as regular coupler made by online process, spigot and sockets are used. The moulded socket will have a suitable internal surface with profiles ribs for insertion of the next pipe into it. The socket end of the pipe to be inserted will have corrugated outer layer.

On first valley segment of corrugated pipe (destined to be pushed into the coupler) one elastomeric rubber ring needs to be placed which is pushed into the coupler socket. This provides sufficient gripping lock and leak proof joint. Similar system is also used for fabricated accessories or moulded fittings required such as tee, bends, elbows, reducer end caps for the purpose of installation of the system related to drainage/sewerage. For quality connections following steps are to be ensured, failing which the performance aspects are to be severely compromised:

- The non-coupler end needs to be thoroughly cleared and shall be free from any foreign material.
- Use a clean rag or brush to lubricate the non-coupler end with lubricant.
- Clean and lubricate the coupler end of the pipe to be laid in similar manner.
- Lubricate the exposed gasket in the same manner with pipe lubricant.
- Keep the lubricated non-coupler end free from dirt, backfill material, and foreign matter so that the joint integrity is not compromised.
- Push the coupler into non-coupler and align properly. Always push coupler end into non-coupler end.

For smaller diameter pipes simple manual insertion shall be sufficient. In every methodology, it should be ensured that the coupler end is adequately 'homed' within non-coupler end to ensure installation and tight joining seal. Therefore, prior to insertion always place a homing mark on appropriate corrugation of the non-coupler end.

Sewerage/drainage system often encounters connecting pipes of different materials/sizes, etc. The fittings or adapters specifically designed for the purpose are available. A selection of fittings designed to make the transition from one material directly to another are also available. In few cases, fitting may need to be used in combination with separate manufacturer's gasket or coupler to give proper effect to the transition.

4.8.4 Backfill:

In general, material used for construction of backfill envelop around the pipe comprises the following:

- Initial backfill.
- Side fill and
- Top backfill.

The material for backfill envelop shall be as per the structural design of flexible buried conduit. It can be the same material that were removed in the course of excavation, or it can be fine sand/course sand/gravel depending on the over burden and superimposed load, but it should be the concrete which invariably induces undesired rigidity in the system.

The remaining portion of backfilling shall be the materials that were removed in the course of excavation. These materials shall consist of clean earth and shall be free from large clod or stone above 75 mm, ashes, refuse and other injurious materials.

After completion of laying of pipes, etc, first the backfill envelope shall be constructed as per design around pipe. Voids must be eliminated by knifing under and around pipe or by some other technique and compacted with necessary watering, either by hand rammers or compactors to a possible maximum level of proctor density.

Backfilling shall start only after ensuring the water tightness test of joints for the concerned sewer segments. However, partial filling may be done keeping the joints open.

Precautions shall be taken against floatation as per the specified methodology and the minimum required cover.

4.9 Measurement- Pipes

- The unit of measurement shall be linear metre to the nearest centimetre.
- All CI / UPVC / HDPE pipes shall be measured in running metre correct to a centimetre for the finished work which shall include fittings e.g., bends, tees, elbows, reducers, crosses, sockets, nipples, nuts, unions etc. The length shall be taken along centre line of the pipes and fittings. No allowance shall be made for the portions of pipe lengths entering the sockets of the adjacent pipes. All pipes and fittings shall be classified according to their diameter, method of jointing and fixing substance, quality, and finish. The diameters shall be nominal diameter of internal bore.

5.0 Sewer Appurtenances

This Specification covers the requirements for various pipeline appurtenances like Manholes, Pipe Supports, etc., required to be provided for sewage gravity network.

5.1 Manholes

Manholes shall be constructed at places as per the drawings and as directed by PMC/Project Engineer.

- Excavation shall be done in accordance with specification provided earlier.
- The manholes shall be Rectangular and constructed of reinforced cement concrete (RCC) at the location as shown in the drawing.
- The manhole spacing in general shall be 30m or more, as specified in the construction drawings and at every junction, change in direction or change in diameter of pipe or as per the directions of PMC/Project Engineer.
- The Manhole dimensions and other details shall be as per the drawings.

- The manhole cover and frame shall be heavy duty SFRC for vehicular traffic area and shall be capable of withstanding Class AA loading as per IRC and shall conform to IS: 12592 (Part I & II).
- The inspection and testing of manhole frames and covers shall be done at factory in presence of PMC/Project Engineer and the cost of such inspection shall be made by the contractor and shall be deemed part of the pipeline works.
- The entire height of the manhole shall be tested for water tightness by closing both the incoming and outgoing ends of the sewer and filling the manhole with water and drop in water level not more than 50mm per 24 hours shall be permitted. The Contractor at his own cost shall arrange the required water for testing and other requirements.

Excavation

Excavation, shoring, dewatering etc. for the pits of manholes shall be done in accordance with specification.

i. Cement concrete channel

The channel for the manhole shall be constructed in cement concrete of M15 grade. Both sides of the channel shall be taken up to the level of the crown of the outgoing sewer. They shall be benched up in concrete extended vertically 50mm above and rendered in cement mortar (1:2) of 20 mm thickness and formed to a slope of 1 in 6 towards the channel.

The branch channels also be similarly constructed with respect to the benching but at their junctions with main channel, an appropriate fall, if required suitably rounded off, in the direction of flow in main channel shall be given.

ii. Pipe entering or leaving manhole

Whenever a pipe enters or leaves a manhole, the pipe shall be encased with the concrete all around the pipes covering the joints.

iii. Rungs / Foot Steps

Rungs / footsteps shall be provided in all manholes and shall be Manufacture and conforms to the dimensions of IS 5455:1969 are reinforcement encapsulated with PVC. The surface finish shall have 2mm tread on top by ribbing or chequering. These rungs may be 300 mm apart vertically and shall project a minimum of 100 mm beyond the finished surface of the manhole wall. The top rung shall be 450 mm below the manhole cover and the lowest not more than 300 mm above the benching. Rungs shall be tested as per IS and approved before usage.

iv. Frame And Covers

Frame and covers for manholes shall be of required type and dimensions as per the relevant drawings.

Following information shall be clearly marked on each cover.

- a. Year of manufacture
- b. Identification mark of the purchaser
- c. Sewer
- d. Arrow showing direction of flow
- e. Name of manufacturer / Trademark

5.1.1 Steel Fibre Reinforced Concrete (SFRC) / Fiber Reinforced Polymer (FRP) Frame and Cover

Steel Fibre Reinforced Concrete (SFRC) frame and cover shall be as manufactured as per IS 12592. (Latest edition). Fiber Reinforced Polymer (FRP) frame and cover shall be manufactured as per BS EN-124 (latest edition). The contractor to submit the structural design and drawing of frame and cover and get it approved before manufacturing the same.

5.1.2 Drop Manhole

When a sewer connects a main sewer, and where the difference in level between water line (peak flow levels) of main line and the invert level of branch line is more than 600 mm or a drop of more than 600 mm is required to be given in the same sewer line and it is uneconomical or impractical to arrange the connection within 600 mm, a drop connection shall be provided for which a manhole shall be constructed as per relevant drawing, incorporating a vertical drop pipe from the higher sewer to the lower one. A continuation of the branch sewer should be built through the shaft wall to form a rodding and inspection eye, which should be provided with a half blank flange. The diameter of the back drop should be at least as large as that of the incoming pipe. The drop pipe should terminate at its lower end with a plain or duck-foot bend turned so as to discharge its flow at 45 degrees or less to the direction of the flow in the main sewer. The pipe, unless of cast iron, shall be surrounded with 150 mm thick concrete.

5.2 Measurement - Manholes

The depth of manhole shall be measure from the top of cover to the invert level of the deepest outgoing sewer from the manhole. The relevant items of manhole quoted as per specifications, drawings and BOQ provisions. The measurement shall be per number basis and as per the actual depth of manhole constructed.

Notes:

If any damage is caused to the other services such as water supply pipeline, sewer, cable/ other utilities etc. during the construction of manholes Contractor shall be held responsible for the same and shall replace the damaged services at his own cost to the full satisfaction of the PMC/Project Engineer.

The interior of manholes shall be cleared of all debris after construction and before testing the same for water tightness by Contractor at his own cost.

Water for testing of manholes along with pipeline shall be arranged by Contractor at his own cost.

LEED GUIDELINES

CONTENTS

1. Pre-Construction Measures	3
2. Dring Construction	4
3. Adhesive	7
4. Paints & coatings	8
5. Carpet	9
6. Resins	9

1. Pre-Construction Measures

1.1 Erosion and sedimentation plan:

An erosion and sedimentation plan needs to be developed to prevent loss of soil during construction by storm water runoff & wind erosion, prevent sedimentation of storm sewer and polluting the air with dust and particulate matter and project needs to implement the applicable measures at site.

- a) Measures such as temporary seeding, permanent seeding, mulching, silt fencing, sedimentation traps etc. can be taken to ensure control of erosion due to wind and storm water runoff.
- b) Top 200 mm of the fertile soil needs to be preserved at site either by covering the same with tarpaulin sheet or create permanent / temporary landscaping over the same. The preserved soil should be used for landscaping in future.
- c) Entire site needs to be barricaded up to the height of 3 meters to prevent the topsoil being carried away due to wind erosion.
- d) Sedimentation trench along with the catchment basin should be constructed at the periphery of the site to prevent the loss of topsoil / sediments being carried away by storm water runoff.
- e) Wheel washing to be considered at site, to ensure that sediments will not be carried away due to vehicular movement.

The civil contractor shall undertake these measures during the construction stage. Photographs of various measures at the site need to be taken by the civil contractor. It is the responsibility of the contractor to ensure that always during excavation and construction these measures are strictly followed.

To assess site conditions before design to evaluate sustainable options and inform related decisions about site design.

Civil contractor / Architect to submit the Site Survey document indicating the following

- **Topography.** Contour mapping, unique topographic features, slope stability risks.
- **Hydrology.** Flood hazard areas, delineated wetlands, lakes, streams, shorelines, rainwater collection and reuse opportunities.
- **Climate.** Solar exposure, heat island effect potential, seasonal sun angles, prevailing winds, monthly precipitation and temperature ranges.
- **Vegetation.** Primary vegetation types, greenfield area, significant tree mapping, threatened or endangered species, unique habitat, invasive plant species.
- **Soils.** Natural Resources Conservation Service soils delineation, prime farmland, healthy soils, previous development, disturbed soils.

- **Human use.** Views, adjacent transportation infrastructure, adjacent properties, construction materials with existing recycle or reuse potential.
- **Human health effects.** Proximity of vulnerable populations, adjacent physical activity opportunities, proximity to major sources of air pollution.

1.2 Storm water management during construction:

Civil contractor to construct rainwater recharge pits / rain water collection tank to harvest the storm water runoff. The rainwater collection / harvesting system should have an filtration mechanism to filter all suspended solids and other materials before recharge into the earth / collected in the rainwater collection tank.

2. During Construction.

2.1 Construction waste management: Civil contractor while construction has to ensure that all waste generated during construction, demolition and land clearing is recycled or salvaged by weight or volume. Civil contractor to keep track of total waste generated at site and either use it on-site for other purposes or resell it some agency outside. A table with the total waste generated in tons or kgs for construction waste including scrap steel, concrete debris, cement and mortar waste, empty paint containers, empty cement bags etc. needs to maintained along with details on what was done with the waste – whether it was resold to scrap agents, reused within our own site for filling or other purposes.

The blank template is enclosed and the same needs to be filled monthly based on site work and updated until completion of project. Also, photos indicating the waste segregation, reuse of the construction waste at site need to be submitted.

Fill the Table below on the actual waste generated during the construction phase. Sample table provided for your guidance

CONSTRUCTION WASTE MANAGEMENT TEMPLATE									
S.No	Description	Source of Waste Generation	Unit	Total Wastage Generated at site	Waste Diverted with in site		Waste diverted out of the site		Waste not resold nor reused
					Total Qty	Usage	Total Qty	Diverted by	Total Qty
1	Reinforcement Steel								
2	MS/GI - Pipe, sheet;								
3	Plastic containers								
4	Aluminium scrap								
5	Carpet								
6	Carton boxes								
7	Polythene covers								

8	Wood								
9	Glass								
10	Cement bags								
11	Solid Block Debris								
12	Granite								
13	Gypsum								
14	Concrete waste								
15	Any other materials								
		Totals							

2.2 Construction IAQ management plan:

While construction various measures have to be taken for storage of materials, housekeeping at site, safety measures for laborers, isolation of constructed/finished areas from areas under construction, dust control etc. Specifically, the following needs to be adhered to and done by contractor at site:

a. SOURCE CONTROL:

Specify finish materials such as paints, carpet, composite wood, adhesives, and sealants that have low toxicity levels, or none at all. The selection of low-emitting materials is covered under EQ Credit 4. The IAQ Management Plan should specify the control measures for materials containing VOCs. Recover, isolate and ventilate containers housing toxic materials. Also, avoid exhaust fumes from idling vehicles and gasoline fueled tools.

b. Pathway Interruption:

During construction, isolate areas of work to prevent contamination of clean or occupied spaces. Depending on the weather conditions, ventilate using 100% outside air to exhaust contaminated air directly to the outside during installation of VOC-emitting materials. Depressurize the work area allowing the air pressure differential between construction and clean areas to contain dust and odours. Provide temporary barriers that contain the construction area.

c. Housekeeping:

Institute cleaning activities designed to control contaminants in building spaces during construction and prior to occupancy. Porous building materials should be protected from exposure to moisture and stored in a clean area prior to installation. Some other strategies are using vacuum cleaners with high efficiency particulate filters, increasing the cleaning frequency and utilizing wetting agents for dust.

d. Scheduling:

Coordinate construction activities to minimize or eliminate disruption of operations in the occupied portions of the building. Construction activities over the duration of the project should be sequenced carefully to minimize the impact on the indoor air quality. It may be necessary to conduct activities with high pollution potential during off-hours, such as on the weekends or in the evenings to allow time for new materials to air out. Plan adequate time to complete work so flush-out and IAQ test procedures can be completed prior to occupancy. Upon completion of construction, replace all filtration media immediately prior to occupancy.

Photos illustrating the following activities needs to be submitted.

1) Pathway Interruption / Barricading Of Finished Areas At Site

The photos should include:

- i Barricading of the site area at which construction works are to take place / are in progress
- ii Barricading voids if any
- iii Demarking of finished areas with barricades

The photos should be categorized in 3 stages:

- i Photos Before construction work starts
- ii Photos during construction
- iii Photos when nearing completion

2.3 Housekeeping at site:

Measures taken for housekeeping before start of construction: It includes photos of housekeeping signage to show that the project promotes indoor cleanliness.

Housekeeping practices followed during construction: It includes photos of laborer's cleaning the area where work is in progress like sweeping floors and walls/glass panels or using vacuum cleaners.

Housekeeping practices followed when nearing completion: It includes photos of laborers cleaning the space after construction work is over.

2.4 Safety Measures:

Safety Measures At Site And Safety Measures For Workers At Site

Photos on PPE (Personal Protection Equipments), Caution Signage and induction training / program for the laborers are required in 3 stages:

- a) Photos Before construction work starts,
- b) Photos during construction,
- c) Photos when nearing completion

It should include photos of signage for protection gears, belt gears, laborers attending the induction camp & fire extinguishing training, laborers working with protection gears like scaffoldings, hard hat, face masks, welding gears, etc.

2.5 Dust Control Measures

Photos of the following are required:

- i Good quality covering for Duct and Diffuser openings from dust
- ii Sealed & Gauged cable ends to prevent entry of water / debris
- iii Covered carpets, workstations and panels
- iv Use Safety & Dust Control Nets in site
- v Dust Control Masks for all workers to prevent from health hazards
- vi Isolation and ventilation of containers housing toxic materials like gases

5) Storage Of Civil, Electrical And Mechanical Materials

Photos of dedicated places of storage of civil and mechanical materials like ducting materials, HVAC Equipment's, AHUs, cement bags, steel rebars, glass, etc. are required. The storage place should be dry, dust free and devoid of contact with water. Porous building materials should be protected from exposure to moisture and stored in a clean area prior to installation.

1) Cement bags stored in moisture free area 2) wood materials / plywood's stored in moisture free areas 3) Paints can stored separately since the same is hazardous in nature. 4) HVAC units covered and stored at site. 5) Protection of electric cables.

3. Adhesive.

Low-Emitting Materials, Adhesives & Sealants

Assess the **general emissions** based on CDPH Standard Method v1.1-2010 or ISO 16000-3: 2010, ISO 16000-6: 2011, ISO 16000-9: 2006, ISO 16000-11:2006 either in conjunction with AgBB, or with French legislation on VOC emission class labeling or AgBB Testing and Evaluation Scheme (2010) or DIBt testing method (2010) and will ensure that the emissions values are less than **5.0 mg/m³**. The VOC limits for adhesives and sealants will be assessed by Lab testing as per SCAQMD Rule 1168 standards as required by LEED US BD+C CORE & SHELL and shall not exceed the following limits:

Architectural Applications	VOC Limit (g/l less water)
Indoor Carpet adhesives	50
Carpet Pad Adhesives	50
Wood Flooring Adhesive	100
Rubber Floor Adhesives	60
Ceramic Tile Adhesives	65
VCT and Asphalt Tile adhesives	50
Dry Wall and Panel Adhesives	50
Cove Base Adhesives	50
Structural Glazing Adhesives	100
Multipurpose Construction Adhesives	70

Substrate Specific Application	VOC Limit (g/l less water)
Metal to Metal	30
Plastic Foams	50
Porous material (except wood)	50
Wood	30
Fibre Glass	80
Specialty Application	VOC Limit (g/l less water)
PVC Welding	510
CPVC Welding	490
ABS Welding	325
Plastic Cement Welding	250
Adhesive Primer for Plastic	550
Contact Adhesive	80
Top & Trim adhesive	250
Special purpose contact adhesive	250
Structural Wood Member adhesives	140
Sheet Applied Rubber lining Operations	850
Sealants	VOC Limit (g/l less water)
Architectural	250
Non membrane Roof	300
Roadway	250
Single-ply roof membrane	450
Others	420
Sealant Primers	VOC Limit:
Architectural Non Porous	250 g/l
Architectural Porous	775 g/l
Others	750 g/l

4. Paints & coatings

Low-Emitting Materials, Paints & coatings

Procure paints with low VOC content. The VOC limits for paints should be assessed by Lab testing as per SCAQMD Rule 1113 standards shall not exceed the following limits:

Paints

- Non-flat - 150 g/L
- Flat (Mat) - 50 g/L
- Anti corrosive/ anti rust - 250 g/L

Coatings

Clear wood finishes

- Varnish - 350 g/L
- Lacquer - 550 g/L
- Floor coatings - 100 g/L
- Stains - 250 g/L

Sealers

- Waterproofing sealer - 250 g/L
- Sanding sealer - 275 g/L
- Other sealers - 200 g/L

VOC limits to be tested as per California Department of Public Health (CDPH) Standard Method v1.1-2010.

5. Carpet:

Use all Carpet with CRI Green label plus certified. This means both carpet and carpet pad/backing has to be CRI Green label plus certified. And the carpet adhesive must meet or not exceed 50g/l of VOC content.

Note: CRI certificate of the carpet to be submitted.

6. Resins:

Use MDF, Plywood, OSB, Veneers, Eco board and other composite wood products without urea formaldehyde resins. The resin used for bonding should be free from urea formaldehyde. We can use these products for doors/partitions/furniture/storage units etc.

Note: Letter from manufacturer confirming the make of resin to be submitted.

LEED V4 GUIDELINES FOR SELECTION OF MATERIALS ,FINISHES & FURNISHING :

Sustainable Building products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. Use Products which has Type III Environmental product declaration

Use Products which are critically reviewed life-cycle assessment conforming to ISO 14044 that have at least a cradle to gate scope

Choose Materials purchased, extracted and manufactured from within 100 miles or the material manufacturer needs to share.

Choose Third party certified products demonstrating an impact reduction (beyond industry average) in 3 or more:

- **Global Warming Potential (CO₂e) [must]**
- Ozone Depletion (CFC-11)
- Acidification (SO₂ or moles H⁺)
- Eutrophication (kg nitrogen or kg phosphate)
- Tropospheric ozone formation (kg Nox or kg ethane)
- Depletion of non renewable energy (MJ)

Recycled Content

- a) It is recommended to use materials with good recycle content such as cement with fly ash, steel with recycle content, glass etc.
- b) Materials manufactured locally/regionally within 160 kms (100 miles) of project site.
- c) To coordinate with respective agencies/manufacturers and get letters confirming the recycled content and distance from manufacturing locations to project site. Specifically cement/ concrete that contains recycle content of 5%, preferably we can also consider Aerocon blocks with good recycle content, steel with 25% recycle content, Glass with 15% recycle content, Aluminium with 25% recycle content and tiles with preferable recycle content.

Recycled content is the sum of postconsumer recycled content plus one-half the pre-consumer recycled content,

Use products sourced from at least five different manufacturers that meet at least one of the responsible sourcing such as materials with recycled content and extraction criteria below for at least 30%, by cost.

FSC Certified Wood

- a) Wood products must be certified by the Forest Stewardship Council or USGBC-approved equivalent.
- b) Invoice confirming the FSC number of the wood procured needs to be submitted.

Building Materials selection strategies:

TABLE 1. Thresholds of compliance with emissions and content standards for 7 categories of materials		
Category	Threshold	Emissions and content requirements
Interior paints and coatings applied on site	At least 90%, by volume, for emissions; 100% for VOC content	- General Emissions Evaluation for paints and coatings applied to walls, floors, and ceilings - VOC content requirements for wet applied products
Interior adhesives and sealants applied on site (including flooring adhesive)	At least 90%, by volume, for emissions; 100% for VOC content	- General Emissions Evaluation - VOC content requirements for wet applied products
Flooring	100%	General Emissions Evaluation
Composite wood	100% not covered by other categories	Composite Wood Evaluation
Ceilings, walls, thermal, and acoustic insulation	100%	- General Emissions Evaluation Healthcare, Schools only Additional insulation requirements
Furniture (include in calculations if part of scope of work)	At least 90%, by cost	Furniture Evaluation
Healthcare and Schools Projects only: Exterior applied products	At least 90%, by volume	Exterior Applied Products

Prefer using the Products which meets the following standards.

Referenced Standard	Product
South Coast Air Quality Management District (SCAQMD)	Non aerosol Adhesives, Sealants, primers, Wood finishes, floor coatings
Green Seal	Aerosol Adhesives, Architectural paints and coatings, interior anti-rust and anti-corrosive paints
Green Label Plus (Carpet and Rug Institute)	Carpets
Green Label (Carpet and Rug Institute)	Carpet Cushion
GREENGUARD	Furniture and Seating
Floorscore	Vinyl, laminate, linoleum, wood, ceramic, rubber flooring

- Properly sequence the installation of materials to avoid contamination of absorptive materials such as insulation, carpeting, gypsum wallboard (If a furniture is installed prior to painting there is a possibility of the furniture absorbing VOC's emitted by paints and will act as a VOC sink. This absorbed VOC will never leave the space even after flushing with outdoor air).

FLOORING

The VOC emissions of all newly installed flooring must meet all limits set by the following, as applicable:

- California Department of Public Health (CDPH) Standard Method v1.1-2010.

INSULATION

The VOC emissions of all newly installed thermal and acoustic insulation inside the waterproofing membrane must meet all limits set by the following, as applicable:

- California Department of Public Health (CDPH) Standard Method v1.1-2010.

FURNITURE AND FURNISHINGS

The VOC emissions of at least 95% (by cost) of all newly purchased furniture and furnishings within the project scope must meet all limits set by the following, as applicable:

- ANSI/BIFMA e3-2011 Furniture Sustainability Standard sections 7.6.1 and 7.6.2, tested in accordance with ANSI/BIFMA Standard Method M7.1-2011.

CONSTRUCTION IAQ MANAGEMENT PLAN: DURING CONSTRUCTION

Construction IAQ management plan: While construction various measures have to be taken for storage of materials, housekeeping at site, safety measures for laborers, isolation of constructed/finished areas from areas under construction, dust control etc. Specifically the following needs to be adhered to and done by contractor at site:

- a. **SOURCE CONTROL:** Specify finish materials such as paints, carpet, composite wood, adhesives, and sealants that have low toxicity levels, or none at all. The selection of low-emitting materials is covered under EQ Credit 4. The IAQ Management Plan should specify the control measures for materials containing VOCs. Recover, isolate and ventilate containers housing toxic materials. Also, avoid exhaust fumes from idling vehicles and gasoline fueled tools.
- b. **Pathway Interruption:** During construction, isolate areas of work to prevent contamination of clean or occupied spaces. Depending on the weather conditions, ventilate using 100% outside air to exhaust contaminated air directly to the outside during installation of VOC-emitting materials. Depressurize the work area allowing the air pressure differential between construction and clean areas to contain dust and odors. Provide temporary barriers that contain the construction area.
- c. **Housekeeping:** Institute cleaning activities designed to control contaminants in building spaces during construction and prior to occupancy. Porous building materials should be protected from exposure to moisture and stored in a clean area prior to installation. Some other strategies are using vacuum cleaners with high efficiency particulate filters, increasing the cleaning frequency and utilizing wetting agents for dust.
- d. **Scheduling:** Coordinate construction activities to minimize or eliminate disruption of operations in the occupied portions of the building. Construction activities over the duration of the project should be sequenced carefully to minimize the impact on the indoor air quality. It may be necessary to conduct activities with high pollution potential during off-hours, such as on the weekends or in the evenings to allow time for new materials to air out. Plan adequate time to complete work so flush-out and IAQ test procedures can be completed prior to occupancy. Upon completion of construction, replace all filtration media immediately prior to occupancy. This activity should be coordinated with the activities and requirements addressed in EQ Credit 3.2 and 5.

The following construction IAQ measures will be adopted:

Cleanliness of air ducts is one of the key factors, which affect the quality of the supply air delivered to the occupancy areas.

This project will adopt the SMACNA (Sheet Metal and Air Conditioning National Contractors Association) guidelines to prevent indoor air quality problems during construction.

For zero tolerance areas like clean rooms and areas for which detailed specifications are defined the level of cleanliness for ducts should be as high as possible. However, if the detailed specification are not defined and for installations which do not have zero tolerance areas SMACNA defines the following measures of duct cleanliness for typical installations which are as under:-

Check coating on ductwork, internal insulation against dusts before leaving manufacturers site. Assign dedicated places for storage of ducting materials & HVAC Equipments. Equipments mentioned above to be stored in such a place such that it does not get affected by the dust, debris, water and other contaminants.

Duct Ends to be covered by plastic sheets. Covering should be a good quality Plastic sheet or a Tarpaulin.

Ducts open ends and overnight pending works must be properly sealed which in turn should be tied firmly with String or Chord and not to be stuck by Cello tape or any other tape which later on come off defeating the purpose.

All construction workers will be provided with dust control masks to prevent from health hazards.

To prevent dust entry from construction site to finished areas demarking with barricades has to be used.

All electrical panels will be covered with water proofing covers to protect from water entry.

All moisture absorbing agents like carpets, furniture, adhesives, sealants, cements etc. will be stored in moisture proof dry room.

Before laying down the carpet, painting work to be scheduled.

Sealed ends shall be visibly examined before storage and if damaged should be resealed.

PHOTOS DEMONSTRATING CREDIT COMPLIANCE:

A minimum of 18 photographs with at least 3 in each of the 5 categories below taken at various times during the construction period is required.

1. HOUSEKEEPING

This should include photos of:

- **Measures taken for housekeeping before start of construction:** It includes photos of housekeeping signage to show that the project promotes indoor cleanliness.
- **Housekeeping practices followed during construction:** It includes photos of laborer's cleaning the area where work is in progress like sweeping floors and walls/glass panels or using vacuum cleaners.
- **Housekeeping practices followed when nearing completion:** It includes photos of laborers cleaning the space after construction work is over.

2. SAFETY MEASURES AT SITE AND SAFETY MEASURES FOR WORKERS AT SITE:

Photos on PPE (Personal Protection Equipments), Caution Signage and induction training/program for the laborers are required in 3 stages:

- Photos Before construction work starts
- Photos during construction
- Photos when nearing completion

It should include photos of signage for protection gears, belt gears, laborers attending the induction camp & fire extinguishing training, laborers working with protection gears like scaffoldings, hard hat, face masks, welding gears, etc.

3. STORAGE OF CIVIL, ELECTRICAL AND MECHANICAL MATERIALS

Photos of dedicated places of storage of civil and mechanical materials like ducting materials, HVAC Equipments, AHUs, cement bags, steel rebars, glass, etc. are required.

The storage place should be dry, dust free and devoid of contact with water. Porous building materials should be protected from exposure to moisture and stored in a clean area prior to installation.

4. DUST CONTROL MEASURES

Photos of the following are required:

- Good quality covering for Duct and Diffuser openings from dust
- Sealed & Gauged cable ends to prevent entry of water / debris
- Covered carpets, workstations and panels
- Use Safety & Dust Control Nets in site
- Dust Control Masks for all workers to prevent from health hazards
- Isolation and ventilation of containers housing toxic materials like gases

5. PATHWAY INTERRUPTION / BARRICADING OF FINISHED AREAS AT SITE

The photos should include:

- Barricading of the site area at which construction works are to take place / are in progress
- Barricading voids if any
- Demarking of finished areas with barricades

The photos should be categorized in 3 stages:

- Photos Before construction work starts
- Photos during construction
- Photos when nearing completion

SITE WASTE MANAGEMENT PLAN

Introduction

A Site Waste Management Plan (SWMP) is a plan that details the amount and type of waste that will be produced on a construction site and how it will be reduced, reused, recycled and disposed off. Material waste is summarized and recorded in a live document that is updated regularly throughout the course of the project and records how the waste streams will be managed. It should also highlight how measures have been taken to reduce the amount of waste that will be produced on site right from planning your design and sizes for various materials in such a manner that they are standardized and have minimum wastages.

The aim of a SWMP is to improve resource efficiency, ensure compliance with waste regulation if any and decrease the amount of waste produced. Implementing a SWMP bring various benefits to your company. These benefits include:

- Better control of risks relating to the materials and waste on your site. “Good Housekeeping” of waste improves site safety.
- A mechanism to demonstrate your leadership in best practices and /or how you manage waste and comply with relevant legislation.
- A tool to provide efficient and effective interaction for wastes arising from your site.
- For a contractor it is a mechanism to demonstrate to your clients how you manage your waste and minimize costs and risks to them.
- A tool to help you fulfill the requirements of your quality and environmental management systems e.g. ISO 14001, BREEAM, Eco Homes, ISO9000.
- A mechanism to demonstrate compliance with contractual requirements from public and private sector clients.
- A system to help you make cost savings by better managing your materials supply, materials storage and handling and better managing your waste for recovery or disposal. The design stage is an important part of the SWMP process in terms of designing out waste from the construction project. However, the main focus of this guidance is on producing a SWMP for use during the construction program.

This document is a brief guide to the key steps in development and implementation of SWMPs including signposting to key sources of information. The guide highlights key actions to be taken in implementing a SWMP. A generic SWMP basis template is also included.

This document should be read in detail before attempting to complete the SWMP template.

Once you have worked through the guidance document you should be able to create your own

SWMP documents and launch your SWMP within your site. Once your first SWMP has been completed it can be reviewed to see if there are improvements in terms of reduced wastage, improved compliance and reduced costs.

Responsibilities

To development and implement a SWMP involves the following:

- Client
- Principle contractor
- Sub-contractors; and
- Site staffs.

Implement SWMPs as standard practice. The principal contractor will be the driving force of a SWMP development and implementation. The success of the implementation of SWMP is highly dependent on top management commitment and support. Top management should ensure availability of adequate resources in implementing a SWMP including delegating responsibility for the implementation of the plan to a 'Project Manager'. First someone needs to be identified to lead on management and implementation of the SWMP. The Project Manager or Site Manager likely to be one who has:

- A good understanding about the day to day activities of the project
- Basic knowledge of environmental issues / waste issues; and
- Sufficient authority to get the necessary support from top management and sub-contractors
- Duties are likely to include: Ensuring waste is managed on site according to the SWMP. This includes ensuring appropriate segregation of waste on-site, making arrangements for the recycling of waste as much as possible or reusing them or the removal of waste from the site if reuse and recycling is not possible. And ensuring all staff and sub-contractors understand their duties in relation to the SWMP. This includes organizing appropriate training (including toolbox talks) and inclusion in the site induction before anyone gets onto the site. Also should be able to ensure correct records and documentation are kept. This includes checking waste transfer documentation and maintenance of documentation relating to waste transfer
- Ensuring compliance with other relevant legislation

The SWMP should also state that all staffs working on site are responsible for adhering to the SWMP. The SWMP should be led with overarching objectives or aims. Objectives are likely to be generic when you first start developing SWMPs. As you gain experience and data from implementing SWMPs you may wish to incorporate targets for reuse and recycling. If you have a Waste Management Policy, Environment Policy or an Environmental Management System then these documents may help to formulate the objectives.

SWMP Objectives

- To take all reasonable steps to ensure that waste management controls are observed.
- To minimize the amount of waste generated and maximize the amount of waste reused and recycled.
- To reuse and recycle as much waste as possible on-site. Where on-site reuse is not possible to identify the most appropriate waste management option in line with the waste hierarchy.
- To manage waste as close as possible to the site location.
- To provide training to improve awareness of waste management issues with all staff and sub-contractors and to improve waste management practices on-site.
- To achieve x% reuse and x% recycling for the whole project (more detail could be added by splitting out inert, active and special (hazardous) wastes).

Identification of Quantities of Waste

The backbone of your SWMP will be the identification of the waste streams that will arise during the project. You should consider the following in characterizing the waste generated:

What: Identify each waste generated in what quantity. It should be specified whether wastes identified are inert, active as this will have implications for handling and waste management options.

Where: Identify where on site the waste will occur. This information is important when planning the type and location of containers and transport of waste around site. Site plans can be utilized.

When: Identify when the waste is likely to be produced. The project timeline/construction program will help with this process. Knowing when the waste will arise can help with the planning of container provision and can help reduce the overall costs of waste management.

Who: Identify whether the waste will be produced by you or the sub-contractor. The various sub contractors may have different responsibilities.

Use your sub-contractors/supply chain to help you identify what waste generated they expect to produce and in what quantity, at what point the waste generated will arise and what they are planning to do to minimize the waste produced. This ideally should be done before actual construction work starts on site. Specification and procurement information, waste transfer notes from previous projects and sub-contractors can help with the waste characterization process. The table below highlights the types of waste that may arise at different stages of the project.

Construction stage	Waste types
Demolition	Concrete, inert, soils, bricks, wood, metal, plastic, glass, plaster, asbestos, electrical items, asphalt.
Earthworks/groundworks	Inert, mixed, concrete, soils, green waste.
Substructure	Concrete, metals, packaging, aggregate.
Structural and drainage	Bricks, blocks, glass, timber.
Internal substructure	Blocks, plasterboard, paint and plaster packaging, timber, plastic products, paper and cardboard.
Externals/drainage	Plastic, soils, inert, timber, packaging.

For each waste generated you need to assess and identify waste management options. You should follow the waste hierarchy when selecting options:

- Reduce – minimize the amount of waste you produce
- Reuse – use items as many times as possible
- Recycling – recycle what you can
- Disposal – dispose of what is left in a responsible way

The table below highlights some of the waste management options available.

S No.	Description	Source of Waste Generation at site	Total Wastage Generated at site(in kg / Cum/ Tons)	Total Qty of Waste Diverted within site (in Kg/ Cum/ Tons)	Explanat ion for Waste diverted within site	Total Qty of Waste diverted for recycling /reuse outside the site (In Kg / Cum / Tons)	Explana tion for Waste diverted outside the site	Total Qty of Waste neither reused within the site nor recycled or reused outside but dumped in local landfills (in Kg)
Please note that the below specified explanations are examples of what has been done in other projects. So kindly modify it according to your project as per what you have done actually at site								
1	Reinforce ment Steel							
2	Solid Block Debris							
3	Cement mortar							
4	Brick work waste							
5	Granite							
6	Tiles waste							
7	Glass pieces and waste							
8	False ceiling waste							
9	Wood and Composite wood waste							
10	Cement bags							
11	Paint containers and Other barrels							
12	Other interior debris including carpet pieces, furnishing waste etc.							
13	Any other item not included above							
	TOTAL							

Determine Site Waste Arrangements

Develop a route mapping for waste generated. You will need to formulate a plan for how waste will be moved around site, collected, segregated and moved off site. Arrangements for managing waste on site will need to be considered when determining waste management options. Ideally you will establish a central waste station for the lifetime of the project. However, the nature of the site is likely to present constraints; on a site limited space you are unlikely to have the space for a dedicated waste station. Some of the factors that you should consider during the planning stage are as below:

Complete Site Waste Management Plan Data Sheet

The information collected on waste generated and management options should be compiled into a data sheet and form part of the SWMP document. At a minimum you should record:

- A description of each waste type that will be produced;
- An estimate of the volume of each different waste produced; and
- The waste management options proposed for each waste type e.g. reduce, reuse, and recycle.

You should also complete the data sheet at the end of the project when actual, rather than predicted figures are known. Ideally you will also update the data sheet at regular intervals during the project.

Training and Awareness

Training is essential for an effective SWMP to ensure all staff are motivated and have the skills and resources to implement the plan effectively. Training should be complicit with the SWMP objectives. Those responsible for implementing the SWMP should identify training needs. This can be done through reviewing existing training program, staff qualifications and experiences.

At a minimum those responsible for implementing the SWMP should provide awareness training on waste management to all staff and sub-contractors involved in the project to explain their roles and responsibilities in relation to the implementation of a SWMP and ensure that all people involved in a project are aware of waste management issues. Details of the training to be provided should be included in the SWMP.

Planning Elements

After the waste management options have been identified it is necessary to decide on the final arrangements of how waste management will be organized on site. Many of the planning elements will have been considered in the previous steps. However, it is worth at this point taking stock and ensuring the main aspects of the SWMP plan have been considered and addressed.

Check All Necessary Arrangements in Place to Manage Waste Materials both On and Off Site

A checklist is provided below to take you through additional planning elements that may not have been fully considered under the previous stages.

Planning Element	Check
Have arrangements been made for how materials will be moved around site?	
Has compliance with manual handling regulations if any been considered?	
Have appropriate containers for waste collection and segregation been identified?	
Has an area/s of site been designated for waste management, including segregation?	

Measure

To monitor the success of the SWMP and to secure continuous improvement in future projects it will be necessary to measure defined aspects of SWMP implementation. It is important to decide what you need to measure before the work begins to ensure you can obtain the information necessary. You will need to measure:

- How much waste is produced and what types (e.g. number of full skips)
- How much waste recycled, re-used and disposed of on and off site (e.g. waste transfer/consignment notes); and

You can place the requirement for collection of measurement data on the waste contractor depending on detail required. At a minimum the waste contractor should provide details on a weekly basis for each container removed from site covering:

- The date removed offsite;
- The size of the container;
- The waste type; and
- The tonnage of waste.

Monitor

It is important to monitor the SWMP to make sure it has been correctly implemented and is working as expected. A monitoring strategy should be incorporated into the SWMP. Monitoring is also useful to identify lessons that can be taken forward to future SWMPs developed.

The monitoring strategy can utilize the measurement data and should examine:

- The amount of waste arising compared with that predicted
- The effectiveness of measures relating to the collection and segregation of waste
- Confirmation that the waste being collected for recycling on site is being utilized
- Confirmation that the waste sent off site is being sent to the waste management facilities specified

Progress should be reported back to the workforce. If the SWMP is being successfully implemented then the staff should be congratulated and encouraged to continue. If problems have been identified these can be addressed. Feedback on progress should be part of the training schedule.

Create Document Register

Part of your monitoring plan should include the creation of a document register to be included in the SWMP. This will be a list of all important documents relating to the SWMP and record where these documents can be found. It is important to keep records to benchmark performance, to identify opportunities for improvement.

All documents in relation to SWMP implementation should be easily accessible to staff involved in the project. Important documents will include:

- **Site Waste Management Plan document:** make sure all staff and sub-contractors involved in the project have a copy of the SWMP document. This will remind them of their roles and responsibilities. The document should be updated to reflect changes to the SWMP during the project
- **Training Records:** compilation of all staff training records
- Waste Transfer Notes / Consignment Notes
- Copies of Registered Carrier and Waste Management License documents
- **Meeting minutes:** These documents are important as they will communicate information in relation to SWMP to staff / sub-contractors not able to attend the meetings. Minutes can be kept as a record of follow-up actions for improvements
- The document register should specify how long the documents will be kept on record. Some documents have a certain statutory time for which they need to be kept e.g. Waste Transfer Notes should be kept for a minimum of 2 years. In other cases it is up to individual companies to determine how long to keep documents

Collate Contact Details for Contractors

It is important to identify all those involved with the SWMP and to provide contact details so they can be easily identified. A list of both sub-contractors and waste contractors should be included in the SWMP. Contact names should be identified for each company.

Review and Evaluation

At the end of the project you should review and evaluate how the SWMP has been implemented. It is important that lessons learnt and information gained feeds into subsequent SWMPs developed. For instance:

- Data collected will provide information on the types of waste that will arise from different activities and in what quantities
- Data collected will give an indication of what levels of recycling can be achieved. These may be greater or less than was anticipated when the SWMP was first drafted. If the levels of recycling were lower than expected reasons for this should be identified
- Where were forecasts accurate and where did the plan have to be changed during the project. This can be taken from the revision history.
- Any areas where arrangements deviated from the SWMP should be identified and discussions held with those involved to identify a solution for future projects.

Check list:

Action Item	Check
Define responsibilities	
Define objectives	
Characterize waste streams	
Identify management option for each waste stream identified	
Determine site waste arrangements	
Complete SWMP data sheet	
Identify waste management companies in locale	
Check credentials of prospective waste contractors	
Identify additional legal requirements	
Develop training plan	
Check all necessary arrangements in place to manage waste materials both on and off site	
Develop method of collecting data	
Establish monitoring strategy	
Create document register	
Collate contact details for contractors	
Review and evaluate SWMP	

ACTION LIST

1. Contractor to identify one or more places to segregate and store the construction debris. This area should be clearly marked and photographs of the same to be taken.

2. Classify the construction debris into two- Debris that can be recycled on site and debris that can be sold for recycling or as scrap.
3. Maintain copies of delivery challans and/or gate passes for scrap taken off-site for recycling including steel, Aluminium, glass, plastics, paint cans, cement bags, gypsum, etc.
4. For scrap reuse within the site such as broken brick refill, etc take photographs of the recycling measure used.
5. Fill the construction waste management tracker template provided here on page 6 regularly and submit the consolidated calculation.

EROSION AND SEDIMENT CONTROL PLAN GUIDE

The main intent of this plan is to reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation. The project team should select the most practical and effective practices to control erosion and prevent sediment from leaving the site. The plan should be organized and presented in a clear, concise manner. Sufficient design and background information should be included to facilitate review by erosion control personnel. Construction details should be precise and clear for use by an experienced general contractor.

An acceptable erosion and sedimentation control plan must contain:

1. Brief narrative
2. Construction schedule
3. Preservation of top soil and limiting disturbance at site
4. Sequence of implementation
5. Maintenance plan
6. Vicinity map
7. Site topographic map
8. Site development plan
9. Erosion and sedimentation control plan drawing
10. Vegetative plan
11. Supporting calculations
12. Checklists

CONSTRUCTION SCHEDULE

1. Obtain plan approval and other applicable permits.
2. Barricade the work area and mark the area for protection.
3. Hold preconstruction conference at least one week prior to starting construction.
4. Install sediment basin as the first construction activity.
5. Install storm drain with block and gravel inlet protection at construction entrance/exit.
6. Install temporary gravel construction entrance/exit.
7. Construct temporary diversions above proposed building sites. Install level spreader and sediment trap and vegetate disturbed areas.
8. Rough grade site, stockpile topsoil, construct channels, install culverts and outlet protection, and install sediment fence as needed. Maintain diversions along top of fill slope daily. NOTE: A temporary diversion will be constructed across the middle of the graded area to reduce slope length and the bare areas mulched should grading be discontinued for more than 3 weeks.
9. Finish the slopes around buildings as soon as rough grading is complete. Leave the surface slightly roughened and vegetate and mulch immediately.
10. Complete final grading for roads and parking and stabilize with gravel.
11. Complete final grading for buildings.
12. Complete final grading of grounds, topsoil critical areas, and permanently vegetate, landscape, and mulch.
13. Install riprap outlet channel and extend riprap to pipe outlet under entrance road.
14. All erosion and sediment control practices will be inspected weekly and after rainfall events. Needed repairs will be made immediately.
15. After site is stabilized, remove all temporary measures and install permanent vegetation on the disturbed areas.
16. ___ months is the estimated time before final stabilization.

PRESERVING TOP SOIL AND LIMITING DISTURBANCE AT SITE

Identify measures for development and stabilization of the site before construction is to be taken up during the dry season.

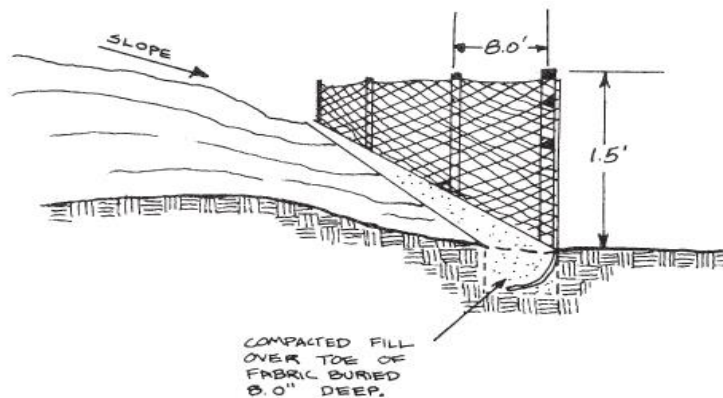
The following measures to be carried out during the period of the year when erosion potential is relatively low.

- Removal of topsoil and stacking the same.
- The top soil (top 20cms) rich in high organic content to be stripped and stacked at suitable location in the site. It shall be reapplied to the site for re-vegetation after construction is complete.
- Fabric fences to be constructed around the area of stock piling to reduce wind caused soil erosion and trap sediments.
- Temporary seeding/mulching techniques to be employed to stabilize stockpiles of topsoil on the site. Mulching of identified areas can be carried out using gravel during construction.
- Native species of plants can be planted to stabilize runoff areas which are free of construction activity.

For water erosion, temporary seeding using sedimentation fence ground disturbance of the site is confined to areas where structures, roads and landscape will continue after construction is complete. These areas were physically demarcated with signs, barriers and tapes to ensure only necessary land area is cleared and soil in other areas is undisturbed. Development activities and equipment movement are also restricted to demarcated areas. Further, these areas were mulched with gravel to prevent erosion. The remaining areas were temporarily sodden with local grasses / vegetation to protect the soil.

Construction Specifications

Construct Sediment fence on low side of topsoil stockpile to prevent sediment from being washed into the drainage system. Fence to be extend around approximately 70 % of the perimeter of the stockpile. Alternatively sediment basins can be constructed by locating posts down slope of fabric to help support fencing.



Sediment Basin

A sediment basin will be constructed in the suitable location of the property. All water from disturbed areas will be directed to the basin before leaving the site. The intent is to ensure no soil leaves the site in case of water run-off.

Soak Pits And Wells

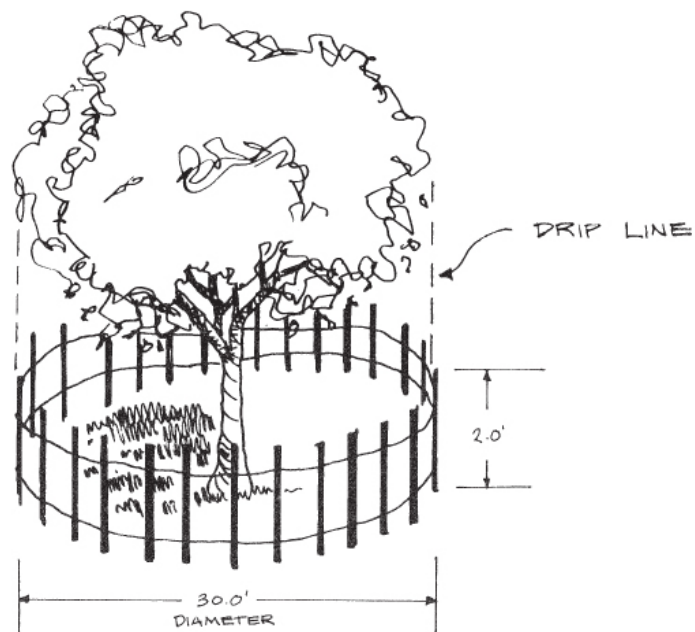
Soak pits and wells would be constructed along the perimeter of the site. The rainwater runoff from rooftop and hard areas is being collected into closed pipe drain and through a sedimentation chamber discharged into a rainwater discharge pit. The suspended matter gets collected in sedimentation chambers, which is cleaned periodically as needed.

Temporary Diversions

Temporary diversions shall be constructed as required to prevent surface runoff from eroding sediment banks. (NOTE: Sediment-free water may be diverted away from the project sediment basin.) This temporary diversion will outlet to the temporary inlet protection device at the construction entrance as the fill elevation increases.

Tree Preservation And Protection

A minimum 2.0 ft high protective fence will be erected around the large tree at the drip line to prevent damage during construction. Sediment fence materials may be used for this purpose.

**Note:**

- SEDIMENT FENCE MATERIAL MAY BE USED TO BUILD FENCE.
- DRIVE STAKES FIRMLY INTO GROUND-AT LEAST 12"

SEQUENCE OF IMPLEMENTATION

1. Development and stabilization measures needed before construction:

These measures have been taken up during the dry season. The following activities were carried out on site during this period of the year when erosion potential is relatively low before commencement of construction activities.

- ❖ Marking of areas to be disturbed during construction activity, stockpiling areas and areas for construction activity.
- ❖ Clearing removal and stock piling of topsoil.
- ❖ Barricading
 - To protect area of stock piled topsoil from wind erosion.
 - To protect areas identified for non-construction activity.

2. Development and stabilization measures during construction

- ❖ Sodding of areas identified for non-construction activity, staging etc.
- ❖ Protecting topsoil with mulching/temporary seeding as described.

3. Development and stabilization measures post-construction

After the landscape and building civil work is completed the following measures will be taken for stabilization in the following sequence: -

- ❖ Grading and development around the building including drains, soak pits, and sub surface drainage over basement slab.
- ❖ Planting of all trees, shrubs, and ground covers etc. within 15 days of finishing grading works.
- ❖ Laying of gravel mulch in areas as required by design.
- ❖ Final connection to the water harvesting pits will be done.
- ❖ The filtration systems, filtration structures and sand filters will be installed only after construction has been completed and the site has been permanently stabilized.

4. Operation and maintenance

Proper operation and maintenance of facilities is necessary for their effective use. The following measures will be followed:

- ❖ Inspection of soak pits and rain wells after every major storm for the first few months after construction. Annual inspection of the soak pits and rain water harvesting pits before the onset of the monsoon season.
- ❖ Periodic removal and replacement of filter media from trench drains and sand filter.
- ❖ Quarterly cleanouts and removal of debris from catch basins, drainage inlets and outlets.
- ❖ Periodic removal and disposal of accumulated sediments. Sediments in infiltration devices will be removed frequently enough to prevent premature failure of systems developed on site due to clogging.

MAINTENANCE PLAN

1. All erosion and sediment control practices will be checked for stability and operation following every runoff-producing rainfall but in no case less than once every week. Any needed repairs will be made immediately to maintain all practices as designed.
2. The sediment basin will be cleaned out when the level of sediment reaches 2.0 ft below the top of the riser. Gravel will be cleaned or replaced when the sediment pool no longer drains properly.
3. Sediment will be removed from the sediment trap and block and gravel inlet protection device when storage capacity has been approximately 50% filled. Gravel will be cleaned or replaced when the sediment pool no longer drains properly.
4. Sediment will be removed from behind the sediment fence when it becomes about 0.5 ft deep at the fence. The sediment fence will be repaired as necessary to maintain a barrier.
5. All seeded areas will be fertilized, reseeded as necessary, and mulched according to specifications in the vegetative plan to maintain a vigorous, dense vegetative cover.

VEGETATION PLAN

AREA	DESCRIPTION	SEASON	SEEDING MIXTURE		SEEDBED PREPARATION	SEEDING METHOD	MULCH	MAINTENANCE	NOTES
			PERMANENT lb/ac	TEMPORARY lb/ac					
Specified below is an example. Kindly specify whichever is more stringent for our project									
1	Steep Slope	Spring	Tall Fescus		SP-1	SM-1	MU-1		
		Summer		German Millet 40	SP-2	SM-2			
2									
3									

SUPPORTING CALCULATION**Runoff Calculations:**

Method: Peak Discharge Method.

NOTE: Other acceptable methods such as Rational Method may also be used.

Calculate peak runoff rate for site during development.

SITE INFORMATION:

1. Site location:
2. Hydrologic soil group:
3. Approximate hydraulic length: _____ feet
4. Average watershed slope: _____ %
5. Site Area: _____ out of which _____ contributing runoff to construction area at outlet.
6. Off-site runoff into project area: _____

Following listed calculations to be provided:

- Calculations of culverts and storm sewers
- Discharge and velocity calculations for open channel and ditch flows
- Design calculations of cross sections and method of stabilization of existing and planned channels (include temporary linings)
- Design calculations and construction details of energy dissipaters below culvert and storm sewer outlets (diameters & apron dimensions)
- Design calculations and dimension of sediment basins
- Surface area and settling efficiency information for proposed sediment traps and/or basins

EROSION and SEDIMENTATION CONTROL PLAN PRELIMINARY REVIEW CHECKLIST

The following items shall be incorporated with respect to specific site conditions, in an erosion & sediment control plan:

Location Information

- Project location (roads, streets, landmarks)
- North arrow and scale

General Site Features (Plan Elements)

- Legend: North arrow, scale, etc.
- Property lines
- Existing contours (topographic lines)
- Proposed contours
- Limits of disturbed area (provide acreage total, delineate limits, and label)
- Planned and existing building locations and elevations
- Planned & existing road locations & elevations
- Lot and/or building numbers
- Geologic features: rock outcrops, seeps, springs, wetland and their limits, streams, lakes, ponds, dams, sea, ocean etc.
- Easements and drainage ways
- Profiles of streets, utilities, ditch lines, etc.
- Stockpiled topsoil or subsoil locations

Erosion Control Measures (On Plan)

- Legend
- Location of temporary measures
- Location of permanent measures
- Construction drawings and details for temporary and permanent measures
- Maintenance requirements of measures
- Contact person responsible for maintenance

Site Drainage Features

- Existing and planned drainage patterns (include off-site areas that drain through project)
- Method of determination of and calculations for Acreage of land being disturbed
- Size and location of culverts and sewers
- Soil information: type, special characteristics
- Soil information below culvert storm outlets
- Name and classification of receiving water course or name of municipal operator (only where storm water discharges are to occur)

Storm Water Calculations

- Pre-construction runoff calculations for each outlet from the site (at peak discharge points)

- Design calculations for peak discharges of runoff (including the construction phase & the final runoff coefficients of the site)
- Design calculations of culverts and storm sewers
- Discharge and velocity calculations for open channel and ditch flows (easement & right-of-ways)
- Design calculations of cross sections and method of stabilization of existing and planned channels (include temporary linings)
- Design calculations and construction details of energy dissipaters below culvert and storm sewer outlets (diameters & apron dimensions)
- Design calculations and dimension of sediment basins
- Surface area and settling efficiency information for proposed sediment traps and/or basins

Vegetative Stabilization

- Area & acreage to be vegetatively stabilized
- Method of soil preparation
- Seed type & rates (temporary & permanent)
- Fertilizer type and rates
- Mulch type and rates

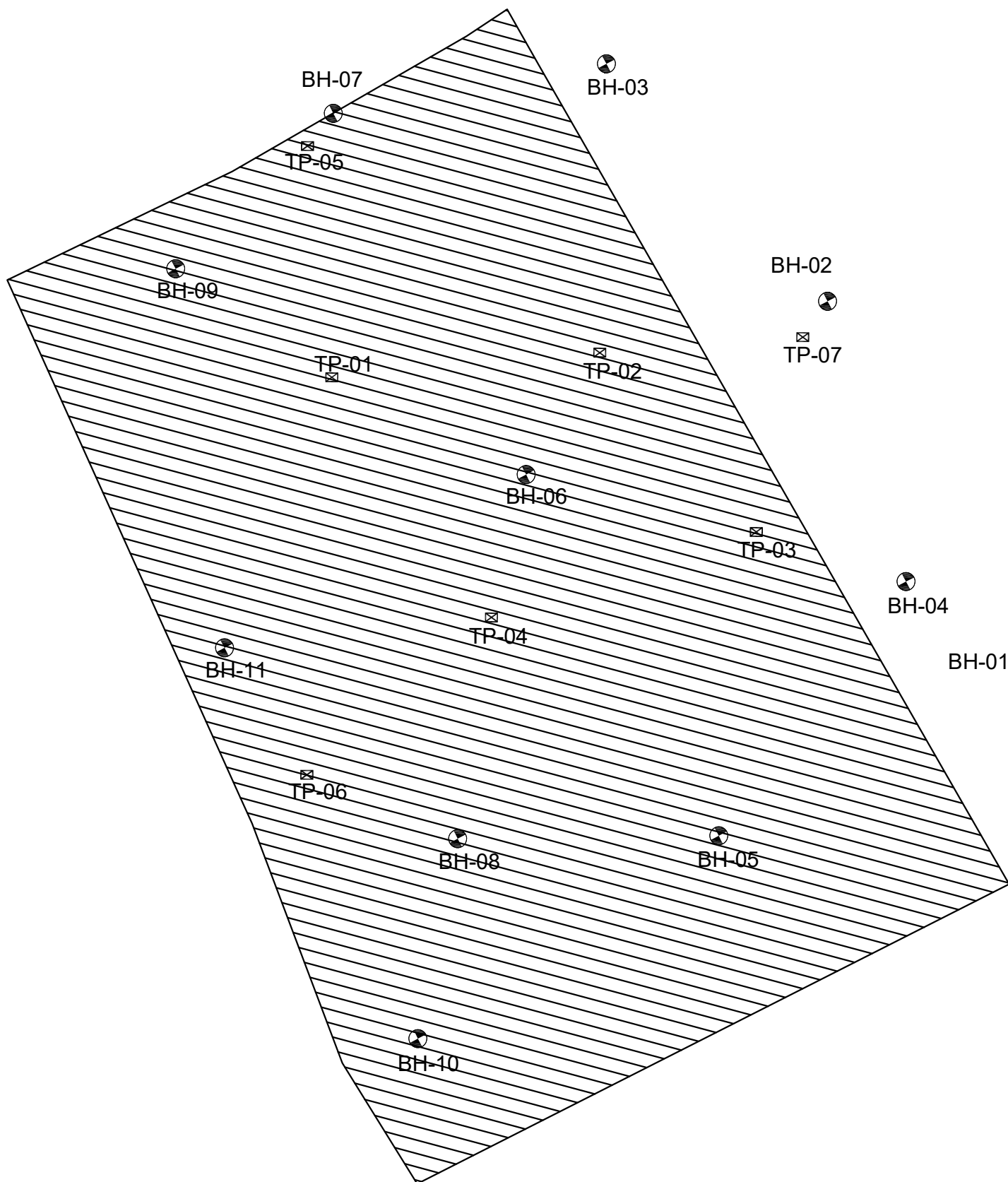
Note: Plan should include provisions for groundcover on exposed slopes within 21 calendar days following completion of any phase of grading; permanent groundcover for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction or development.

Narrative and Construction Sequence

- Narrative describing the nature & purpose of the construction activity
- Construction sequence related to erosion and sediment control (including installation of critical measures prior to the initiation of the land-disturbing activity & removal of measures after areas they serve are permanently stabilized)
- Bid specifications related only to erosion control

EXTRACT OF SOIL REPORT

ANNEXURE I
PLAN OF BOREHOLE
LOCATION



BOREHOLE LOCATION PLAN

ANNEXURE II **BORELOGS**



Name of Project: Sub Soil Investigation for the Construction of **TIDEL PARK** at Madurai,Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	1		Total depth	15.20 m
Type of Boring	Rotary		Depth of Water Table	2.36 m
RL Value	132.647		Water Loss & Rain occurred	Only Rain occurred
Started on	22.11.2023		Co - ordinates	N 1100429.46
Ended on	22.11.2023			E 188061.53

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	N	Graphical Representation of SPT (N value)											Type of Samples
									0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	1.00	SPT	4	5	4	9												DS
-2.00 m			2.00	SPT	3	5	8	13												DS
-3.00 m		Brown coloured Sand (Filledup soil)	3.00	SPT	8	16	21	37												DS
-4.00 m		Brown coloured Sand mixed with Clay	4.00	SPT	18	15	24	39												DS
-5.50 m			5.50	SPT	29	34	43	77												DS
-7.00 m		Brown coloured Gravel mixed with Sand	7.00	SPT	31	39	45	84												DS
-8.50 m		Brown coloured Sand	8.50	SPT	38	42	49	91												DS
-9.20 m			9.20	SPT	13 cm for 50 blows			>100												DS
-9.33 m			9.33																	
-11.50 m		WEATHERED ROCK (CR=0%&RQD=0%)	11.50	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-12.20 m			12.20	SPT	9 cm for 50 blows			>100												WS
-15.20 m			15.20	SPT	2 cm for 50 blows			>100												WS

DS - Disturbed soil sample

WS -Washing Sample

CR = Core Recovery

RQD = Rock Quality Designation



Name of Project: Sub Soil Investigation for the Construction of **TIDEL PARK** at Madurai, Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	2		Total depth	15.00 m
Type of Boring	Rotary		Depth of Water Table	2.43 m
RL Value	132.713		Water Loss & Rain occurred	NO
Started on	23.11.2023		Co - ordinates	N 1100493.43
Ended on	23.11.2023			E 188024.49

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	N	Graphical Representation of SPT (N value)											Type of Samples
									0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Grey coloured Sand mixed with Clay (Filledup soil)	1.00	SPT	3	3	4	7												DS
-2.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	2.00	SPT	4	6	9	15												DS
-3.00 m		Brown coloured Sand mixed with Gravel (Filledup soil)	3.00	SPT	5	10	17	27												DS
-4.00 m		Grey coloured Sand mixed with Clay	4.00	SPT	12	17	24	41												DS
-5.50 m			5.50	SPT	18	25	28	53												DS
-7.00 m		Grey coloured Sand mixed with Gravel	7.00	SPT	23	35	41	76												DS
-8.50 m		Grey coloured Sand mixed with Clay	8.50	SPT	31	40	47	87												DS
-9.00 m		Grey coloured Sand mixed with Gravel	9.00	SPT	10 cm for 50 blows			>100												DS
-9.10 m			9.10																	
-11.50 m		WEATHERED ROCK (CR=0%&RQD=0%)	11.50	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-12.00 m			12.00	SPT	7 cm for 50 blows			>100												WS
-13.50 m			13.50	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-15.00 m			15.00	SPT	1 cm for 50 blows			>100												WS

DS - Disturbed soil sample

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Name of Project: Sub Soil Investigation for the Construction of TIDEL PARK at Madurai, Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	3		Total depth	15.60 m
Type of Boring	Rotary		Depth of Water Table	2.20 m
RL Value	132.903		Water Loss & Rain occurred	NO
Started on	24.11.2023		Co - ordinates	N 1100539.22
Ended on	24.11.2023			E 187981.80

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	N	Graphical Representation of SPT (N value)											Type of Samples
									0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	1.00	SPT	4	5	6	11												DS
-2.00 m		Brown coloured Sand mixed with Gravel (Filledup soil)	2.00	SPT	5	4	2	6												DS
-3.00 m		Brown coloured Sand (Filledup soil)	3.00	SPT	2	1	3	4												DS
-4.00 m		Grey coloured Sand mixed with Clay	4.00	SPT	12	27	34	61												DS
-5.50 m			5.50	SPT	18	24	31	55												DS
-7.00 m		Brown coloured Sand mixed with Clay	7.00	SPT	25	34	41	75												DS
-8.50 m		Brown coloured Sand mixed with Gravel	8.50	SPT	28	37	44	81												DS
-9.60 m			9.60	SPT	12 cm for 50 blows			>100												DS
-9.72 m			9.72																	
-11.50 m		WEATHERED ROCK (CR=0%&RQD=0%)	11.50	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-12.60 m			12.60	SPT	7 cm for 50 blows			>100												WS
-14.00 m			14.00	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-15.60 m			15.60	SPT	3 cm for 50 blows			>100												WS

DS - Disturbed soil sample

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RQD = Rock Quality Designation



Name of Project: Sub Soil Investigation for the Construction of **TIDEL PARK** at Madurai, Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	4		Total depth	15.00 m
Type of Boring	Rotary		Depth of Water Table	2.20 m
RL Value	132.795		Water Loss & Rain occurred	Only Rain occurred
Started on	25.11.2023		Co - ordinates	N 1100439.34
Ended on	25.11.2023			E 188039.63

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	N	Graphical Representation of SPT (N value)											Type of Samples
									0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Sand mixed with Gravel	1.00	SPT	3	3	5	8												DS
-2.00 m		Brown coloured Clay mixed with Sand	2.00	SPT	4	5	5	10												DS
-3.00 m		Brown coloured Sand	3.00	SPT	3	3	4	7												DS
-4.00 m		Grey coloured Sand mixed with Clay	4.00	SPT	24	28	31	59												DS
-5.50 m			5.50	SPT	26	34	38	72												DS
-7.00 m			7.00	SPT	31	37	42	79												DS
-8.80 m		Brown coloured Sand	8.80	SPT	13 cm for 50 blows			>100												DS
-8.93 m			8.93																	
-10.00 m		WEATHERED ROCK (CR=0%&RQD=0%)	10.00	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-11.80 m			11.80	SPT	10 cm for 50 blows			>100												WS
-13.00 m			13.00	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-15.00 m			15.00	SPT	4 cm for 50 blows			>100												WS

DS - Disturbed soil sample

WS -Washing Sample

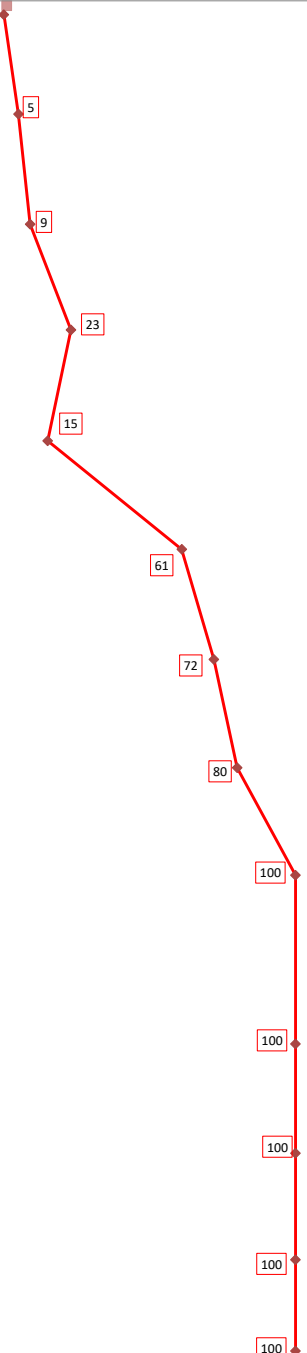
CR = Core Recovery

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Name of Project: Sub Soil Investigation for the Construction of **TIDEL PARK** at Madurai, Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	5		Total depth	16.20 m
Type of Boring	Rotary		Depth of Water Table	2.30 m
RL Value	133.09		Water Loss & Rain occurred	NO
Started on	25.11.2023		Co - ordinates	N 1100390.31
Ended on	26.11.2023			E 188003.48

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	N	Graphical Representation of SPT (N value)											Type of Samples
									0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	1.00	SPT	2	3	2	5		DS										
-2.00 m			2.00	SPT	2	4	5	9			DS									
-3.00 m			3.00	SPT	5	10	13	23				DS								
-4.00 m	4.00	SPT	8	9	6	15	DS													
-5.50 m	Brown coloured Sand mixed with Clay	5.50	SPT	23	29	32		61					DS							
-7.00 m		7.00	SPT	27	35	37		72						DS						
-8.50 m	Brown coloured Sand	8.50	SPT	33	38	42		80					DS							
-10.20 m		10.20	SPT	56	13 cm for 50 blows			>100						DS						
-10.48 m		10.48													WS					
-11.50 m	WEATHERED ROCK (CR=0%&RQD=0%)	11.50	SPT	SPT REBOUND (NO PENETRATION)				>100					WS							
-13.20 m		13.20	SPT	9 cm for 50 blows				>100						WS						
-14.50 m		14.50	SPT	SPT REBOUND (NO PENETRATION)				>100								WS				
-16.20 m		16.20	SPT	4 cm for 50 blows				>100									WS			

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WS -Washing Sample

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Name of Project: Sub Soil Investigation for the Construction of **TIDEL PARK** at Madurai, Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	6		Total depth	15.30 m
Type of Boring	Rotary		Depth of Water Table	2.15 m
RL Value	132.876		Water Loss & Rain occurred	NO
Started on	26.11.2023		Co - ordinates	N 1100459.99
Ended on	26.11.2023			E 187966.30

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	N	Graphical Representation of SPT (N value)											Type of Samples
									0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Sand mixed with Clay	1.00	SPT	3	4	3	7												DS
-2.00 m			2.00	SPT	4	5	5	10												DS
-3.00 m			3.00	SPT	5	4	7	11												DS
-4.00 m			4.00	SPT	13	17	22	39												DS
-5.50 m			5.50	SPT	16	26	33	59												DS
-7.00 m			7.00	SPT	23	28	37	65												DS
-8.50 m			8.50	SPT	38	32	46	78												DS
-9.30 m		Brown coloured Sand	9.30	SPT	27	10 cm for 50 blows		>100												DS
-9.55 m			9.55																	DS
-11.50 m		WEATHERED ROCK (CR=0%&RQD=0%)	11.50	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-12.30 m			12.30	SPT	12 cm for 50 blows			>100												WS
-14.50 m			14.50	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-15.30 m			15.30	SPT	7 cm for 50 blows			>100												WS

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Name of Project: Sub Soil Investigation for the Construction of **TIDEL PARK** at Madurai, Tamilnadu.

Report No		159/ GRB/ 2023-24 Dt :22.11.2023		BORELOG SHEET					Dia of Boring		150 mm/Nx									
Bore Hole No.		7							Total depth		15.20 m									
Type of Boring		Rotary							Depth of Water Table		2.70 m									
RL Value		132.614							Water Loss & Rain occurred		Only Rain occurred									
Started on		26.11.2023							Co - ordinates		N 1100529.67									
Ended on		26.11.2023									E 187929.12									
Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	N	Graphical Representation of SPT (N value)											Type of Samples
									0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	1.00	SPT	4	5	6	11												DS
-2.00 m			2.00	SPT	4	8	6	14	DS											
-3.00 m		Brown coloured Sand mixed with Clay	3.00	SPT	12	17	18	35												DS
-4.00 m			4.00	SPT	16	21	26	47												DS
-5.50 m			5.50	SPT	24	29	33	62												DS
-7.00 m			7.00	SPT	30	37	42	79												DS
-8.50 m			8.50	SPT	41	39	46	85												DS
-10.20 m			10.20	SPT	13 cm for 50 blows			>100												DS
-10.33 m	10.33																			
-11.50 m		WEATHERED ROCK (CR=0%&RQD=0%)	11.50	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-13.20 m			13.20	SPT	4 cm for 50 blows			>100												WS
-14.50 m			14.50	SPT	SPT REBOUND (NO PENETRATION)			>100												WS
-15.20 m			15.20	SPT	2 cm for 50 blows			>100												WS

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Name of Project: Sub Soil Investigation for the Construction of **TIDEL PARK** at Madurai,Tamilnadu.

Report No		159/ GRB/ 2023-24 Dt :22.11.2023		BORELOG SHEET					Dia of Boring		150 mm/Nx																
Bore Hole No.		8							Total depth		15.00 m																
Type of Boring		Rotary							Depth of Water Table		2.43 m																
RL Value		132.920							Water Loss & Rain occurred		NO																
Started on		28.11.2023							Co - ordinates		N 1100389.74																
Ended on		28.11.2023									E 187953.12																
Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	UDS	N	Graphical Representation of SPT (N value)																Type of Samples	
										0	10	20	30	40	50	60	70	80	90	100							
-1.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	1.00	SPT	1	1	1	-	2																	DS	
-2.00 m			2.00	SPT	3	1	2	-	3																	DS	
-3.00 m		Brown coloured Clay mixed with Sand (Filledup soil)	3.00	SPT	5	8	12	-	20																	DS	
-4.00 m		Grey coloured Clay mixed with Sand	4.00	SPT	12	16	19	-	35																	DS	
-5.50 m		Grey coloured Sand mixed with Gravel	5.50	SPT	18	21	26	-	47																	DS	
-7.00 m		Brown coloured Sand mixed with Gravel	7.00	SPT	27	13 cm for 50 blows		1	>100																	DS	
-7.28 m			7.28																								
-8.50 m		WEATHERED ROCK (CR=0%&RQD=0%)	8.50	SPT	SPT REBOUND (NO PENETRATION)			-	>100																	WS	
-10.00 m			10.00	SPT	10 cm for 50 blows			-	>100																	WS	
-11.50 m			11.50	SPT	SPT REBOUND (NO PENETRATION)			-	>100																	WS	
-12.00 m			12.00	SPT	2 cm for 50 blows			-	>100																	WS	

DS - Disturbed soil sample

CR = Core Recovery

WS -Washing Sample

RQD = Rock Quality Designation



Name of Project: Sub Soil Investigation for the Construction of **TIDEL PARK** at Madurai,Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	9		Total depth	15.00 m
Type of Boring	Rotary		Depth of Water Table	2.20 m
RL Value	132.664		Water Loss & Rain occurred	Only Rain occurred
Started on	28.11.2023		Co - ordinates	N 1100499.69
Ended on	28.11.2023			E 187898.68

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	UDS	N	Graphical Representation of SPT (N value)											Type of Samples
										0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	1.00	SPT	2	3	3	-	6												DS
-2.00 m		Grey coloured Sand mixed with Clay (Filledup soil)	2.00	SPT	3	3	4	-	7												DS
-3.00 m		Brown coloured Sand mixed with Gravel (Filledup soil)	3.00	SPT	8	13	21	-	34												DS
-4.00 m		Grey coloured Sand mixed with Clay	4.00	SPT	13	18	16	-	34												DS
-5.50 m		Brown coloured Sand mixed with Gravel	5.50	SPT	21	24	28	-	52												DS
-7.20 m		Brown coloured Sand	7.20	SPT	10 cm for 50 blows			1	>100												DS
-7.30 m			7.30																		
-8.50 m		WEATHERED ROCK (CR=0%&RQD=0%)	8.50	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-10.20 m			10.20	SPT	4 cm for 50 blows			-	>100												WS
-11.50 m			11.50	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-13.20 m			13.20	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-15.00 m			15.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS

DS - Disturbed soil sample

WS -Washing Sample

CR = Core Recovery

RQD = Rock Quality Designation



Name of Project: Sub Soil Investigation for the Construction of TIDEL PARK at Madurai,Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	10		Total depth	15.00 m
Type of Boring	Rotary		Depth of Water Table	2.60 m
RL Value	132.801		Water Loss & Rain occurred	NO
Started on	29.11.2023		Co - ordinates	N 1100351.17
Ended on	29.11.2023			E 187945.44

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	UDS	N	Graphical Representation of SPT (N value)											Type of Samples
										0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	1.00	SPT	2	1	2	-	3												DS
-2.00 m		Brown coloured Clay mixed with Sand (Filledup soil)	2.00	SPT	2	3	2	-	5												DS
-3.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	3.00	SPT	6	8	12	-	20												DS
-4.00 m		Brown coloured Sand mixed with Clay	4.00	SPT	3	4	6	-	10												DS
-5.50 m		Brown coloured Clay mixed with Sand	5.50	SPT	13	21	26	-	47												DS
-7.00 m		Brown coloured Sand	7.00	SPT	18	23	29	-	52												DS
-8.30 m		Brown coloured Sand mixed with Gravel	8.30	SPT	6 cm for 50 blows			1	>100												DS
-8.36 m			8.36																		
-10.00 m		WEATHERED ROCK (CR=0%&RQD=0%)	10.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-11.30 m			11.30	SPT	3 cm for 50 blows			-	>100												WS
-13.00 m			13.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-15.00 m			15.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS

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Name of Project: Sub Soil Investigation for the Construction of **TIDEL PARK** at Madurai,Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	11		Total depth	16.50 m
Type of Boring	Rotary		Depth of Water Table	2.40 m
RL Value	132.448		Water Loss & Rain occurred	NO
Started on	29.11.2023		Co - ordinates	N 1100426.55
Ended on	30.11.2023			E 187908.11

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	UDS	N	Graphical Representation of SPT (N value)											Type of Samples
										0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Sand mixed with Clay	1.00	SPT	2	2	3	-	5												DS
-2.00 m		Grey coloured Sand mixed with Clay	2.00	SPT	3	4	5	-	9												DS
-3.00 m			3.00	SPT	8	15	22	-	37												DS
-4.00 m		Grey coloured Clay mixed with Sand	4.00	SPT	5	8	10	-	18												DS
-5.50 m		Grey coloured Sand mixed with Clay	5.50	SPT	13	17	23	-	40												DS
-7.00 m		Brown coloured Sand	7.00	SPT	21	26	31	-	57												DS
-8.40 m			8.40	SPT	7 cm for 50 blows			1	>100												DS
-8.47 m			8.47																		
-10.00 m		WEATHERED ROCK (CR=0%&RQD=0%)	10.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-11.40 m			11.40	SPT	4 cm for 50 blows			-	>100												WS
-13.00 m			13.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-14.40 m			14.40	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-16.00 m			16.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-16.50 m			16.50	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS

DS - Disturbed soil sample

CR = Core Recovery

WS -Washing Sample

RQD = Rock Quality Designation



Name of Project: Sub Soil Investigation for the Construction of TIDEL PARK at Madurai,Tamilnadu.

Report No	159/ GRB/ 2023-24 Dt :22.11.2023	BORELOG SHEET	Dia of Boring	150 mm/Nx
Bore Hole No.	12		Total depth	15.00 m
Type of Boring	Rotary		Depth of Water Table	1.30 m
RL Value	132.882		Water Loss & Rain occurred	NO
Started on	29.11.2023		Co - ordinates	N 1100501.93
Ended on	30.12.2023			E 187870.79

Depth from Ground level	Soil Profiles	Description of Soil	Depth (m)	Type	15	30	45	UDS	N	Graphical Representation of SPT (N value)											Type of Samples
										0	10	20	30	40	50	60	70	80	90	100	
-1.00 m		Brown coloured Gravel mixed with Sand (Filledup soil)	1.00	SPT	2	3	5	-	8												DS
-2.00 m		Brown coloured Sand mixed with Clay (Filledup soil)	2.00	SPT	3	5	7	-	12												DS
-3.00 m		Brown coloured Sand (Filledup soil)	3.00	SPT	15	21	27	-	48												DS
-4.00 m		Brown coloured Clay mixed with Sand	4.00	SPT	8	13	21	-	34												DS
-5.50 m		Brown coloured Sand mixed with Clay	5.50	SPT	23	18	31	-	49												DS
-7.00 m			7.00	SPT	4 cm for 50 blows			1	>100												DS
-7.04 m			7.04																		
-8.50 m		WEATHERED ROCK (CR=0%&RQD=0%)	8.50	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-10.00 m			10.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-11.50 m			11.50	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-13.00 m			13.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS
-15.00 m			15.00	SPT	SPT REBOUND (NO PENETRATION)			-	>100												WS

DS - Disturbed soil sample

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APPROVED MAKES LIST

VOLUME III APPROVED MAKES LIST- CIVIL AND ARCHITECTURAL WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
A	ADMIXTURE	
1	a. Water reducing plasticizers	MASTERRHEOBUILD SERIES / Master Builder Solutions / FOSROC CHEMICALS / CERA
	b. Set Retarders / Masonry / MCP admixtures	Euclid / Master Builder Solutions / FOSROC /SIKA
	c. Air Entraining Admixture	MAPEI Construction Products India Pvt. Ltd / FOSROC CHEMICALS / CERA CHEM /
	d. Super plasticizers for high performance and slump retainers	MASTER POLYHEED SERIES / Master Builder Solutions / FOSROC CHEMICALS
	e. Water reducing high performance plasticizers and	MATERPOZZOLITH SERIES/ Master Builder Solutions / FOSROC CHEMICALS / CERA CHEM / Euclid /
	f. Super plasticizers for self-compacting concrete-PC based	MASTERGLENIU SERIES / Master Builder Solutions / FOSROC CHEMICALS / CERA CHEM / MAPEI
	g. Super plasticizers for smart dynamic/free flow concrete and	MASTERGLENIU SERIES / Master Builder Solutions / FOSROC CHEMICALS / CERA CHEM / MAPEI
	h. High performance admixtures for shotcrete	MASTERROC SERIES / BASF INDIA LTD / FOSROC CHEMICALS / CERA CHEM /
	i. Liquid Admixture for light weight mortar and concrete	Fosroc Chemicals / CERA CHEM / Master Builder Solutions
	J.Chemical Admixtures & Additives	Fosroc/ Dr Fixit/BASF/ Pidilite/ Sika/ Bal-Endura/MYK Schomburg
B	ANTI-TERMITE TREATMENT	
2	Anti-Termite Pesticides - (Chloropyriphos)	Bayer/ Biflex-TC from FMC/ Hilban from HIL/ Pidilite / Biflex / Madhura / Bifenthrin
C	CEMENT	
3	Cement OPC/ PPC	Ultratech/ ACC/Ramco/Coramandal/Zuari/ Dalmia/ Arasu
4	Cement - White	Birla white / JK
D	EXPANSION FILLER BOARD	
5	Expansion Filler board – Premoulded compressible	Supreme Industries Ltd./ Shalitex -STP
E	REINFORCEMENT STEEL	
6	Reinforcement Steel	SAIL/ TATA (TISCON)/JSW steel/ Jindal / Vizag/ Thirumala
F	RMC	
7	Ready Mixed Concrete (RMC)	CLIENT / ENGINEER Approved RMC Suppliers.In house RMC plant to be established by contractor.
G	SEALANT	
8	Silicon Sealants	Dow Corning/ GE Silicon
9	Polysulphide Sealant	Pidilite/ Fosroc/ Dow corning/ Sika/ MC-bauchemie
H	STRUCTURAL STEEL	
10	Structural Steel	SAIL/ Jindal/ TATA (TISCON)/Apollo/Vizag/Pulkit
I	WATERPROOFING	
11	Waterproofing Compound	Fosroc/ Dr Fixit/ Sika/ BASF/ Pidilite/ CICO
12	Crystalline Integral Waterproofing	Pidilite/ BASF/ Fosroc/ Sika
13	Membrane Waterproofing system	SIKA/ Dr Fixit/ Fosroc/ BASF/ Pidilite
14	Elastomeric Waterproofing system	SIKA/ Dr Fixit/ Fosroc/ HyperDesmo/ BASF/ Pidilite
J	WATER STOPS	
15	Water Stops - Hydrophilic Swellable rubber strip	SIKA/ Hydrotite/BASF/ Fosroc
K	BLOCKWORK	

VOLUME III APPROVED MAKES LIST- CIVIL AND ARCHITECTURAL WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
16	Blockwork-AAC Blocks	Xtralite from Ultratech/ Aerocon from HIL/Renacon/Celcon
17	Blockwork-AAC block joining mortar	Xtralite from Ultratech/ Aerocon from HIL/Renacon/Celcon
18	Solid Blockwork	Premium Quality Solid Block
19	Concrete Blocks	Sobha / APCO / Aeons / Bessar as per IS 2185 Part 1 of Class 3.5.
20	Concrete Blocks for exposed block work	Basant Betons / SOBHA as per IS 2185 Part 1 of Class 3.5.
L	MISCELLANEOUS	
21	Anchor Fastner, Rebar, Chemcial/ Mechanical fastner, Core - cutting, Dry stone cladding clamp, Expandable fastners	Hilti/ fischer
22	Backer rods	Supreme Industries Ltd./ Fosroc
23	Non shrink cementitious precision (anchoring) grout	Fosroc/ Sika/Ardex Endura/ BASF
24	Air transfer grills	Trox/ Ruskin Titus/ Systemair India
25	Precoated Galvanised Sheets	Tata-Blue scope/Jindal/Interarch
26	Stainless Steel	SAIL/ Jindal/ Salem steel/ Tata
27	Stainless Steel Bolts, Washers and Nuts, Pressure plates, screws	Kundan/ Puja/ Atul/ GKW/ knettlefoldl
28	SS clamps, pins	Hafele/ Dorma
29	Adhesives	Laticrete/ KeraKoll/ Pidilite.
30	PVC cover block, plastering mesh,pvc tile spacer,Corner beads	Arpitha exports/ Arpitha / KNG / RAMTECH/ASTRA.
31	Cement Fiber Board	Everest/ NCL Industries (Bison Panel)/ Visaka Industries (V- Next)/ MASE
32	Plastic coated plywood for shuttering	Evergreen Plywood Industries/ Greenply Shuttering Ply / Atchid Shuttering Ply/ Euro Shuttering Ply
33	Synthetic enamel	Asian brand / Apex/ Berger/ ICI
34	Deck Sheeting	JSW / Caurus / TATA
35	Shear Studs	JSW / Interach / Tata / Unbrako
36	Intumescent Paint	JSW / Jotun / Promat / Stanvac
37	2hrs fire rated Vermiculite cementitious	Grace / Promat / Akzonobel
38	Welding Electrodes	Ador / Kisel / GEE Ltd / Modi Arc electrodes
39	Post installed reinforcement connections (rebaring)	Hilti / Fischer / Wruth
40	Fire protection Sealants/ Spray	MAPEI Construction Products India Pvt. Ltd/ HILTI / 3M / Mapeflex Firestop 1200
M	PRECAST ELEMENTS	
41	a.Pre cast Concrete Landscape elements, gratings, kerb, Drain cover	Basant Betton / Everest Precast / VME Precast / AVS Tech / Shivamm / Sobha/ Vyara/ Super Decorative floorings/ KK Manholes & Gratings/ Nimco
42	b. Interlocking pavers	Basant Betton / Everest Precast / VME Precast / AVS Tech / Style Earth / Shivamm / Sobha
	c. Manhole covers /Perforated cover slabs	Basant Betton / Everest Precast / VME Precast
	d. Grass Crete pavers	Basant Betton / Everest Precast / VME Precast /super tiles pavers
	e. Precast Chambers	Basant Betton / Everest Precast / VMEPrecast
43	Hot dipped GI Gratings	Indiana / Gratings India / Cresnet / Fibrocast

VOLUME III APPROVED MAKES LIST– CIVIL AND ARCHITECTURAL WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
44	Weld Mesh Fe-480	Jain net / Megh steel / IJM steels / NBC weld mesh / Viema weld
45	GGBS	JSW / Balaha
N	SURFACE TREATMENTS	
46	a. Curing compounds	CHRYSO® / Dr.Fixit / Pidilite / Fosroc / Don Chemicals / MYK Arment
	b. Water-based curing compounds	MASTERKURE SERIES / Master Builder Solutions / Fosroc Chemicals / CERA CHEM / MAPEI Construction Products India Pvt. Ltd / CHRYSO® / MYK Arment
	c. Resin based curing compounds	MASTERKURE SERIES / Master Builder Solutions / Fosroc Chemicals / CERA CHEM / MYK Arment
	d. Solvent based curing and sealing	Euclid / DOW CHEMICALS / MYK Arment
	e. Polymer based (dry's to silver)	Fosroc Chemicals / FOSROC/ CERA CHEM / Master Builder Solutions
	f. Concrete remover, cleaning and etching agent	Fosroc Chemicals / CERA CHEM
	g. Epoxy based coatings	MASTERPROTECT SERIES / Master Builder Solutions / Fosroc Chemicals / CERA CHEM / Parex Group / MAPEI Construction Products India Pvt. Ltd / CHRYSO SWC / Pidilite / Jotun / Asian Paints /
O	BONDING AGENTS	
47	a. Epoxy resin based bonding agents	MASTERBRACE SERIES / Master Builder Solutions / Fosroc Chemicals / CERA CHEM / Euclid / MAPEI Construction Products India Pvt. Ltd / CHRYSO –SWC / Pidilite / MYK Arment
	b. Acrylic based bonding agents	MASTERFLOW SERIES / Master Builder Solutions / Fosroc Chemicals / CERA CHEM / Parex Group / MAPEI Construction Products India Pvt. Ltd / CHRYSO® / Pidilite / Asian Paints / MYK Arment
	c. Latex Based bonding agents	Euclid /SIKA / MYK Arment
	d. SB rubber based bonding agents:	MASTERFLOW SERIES / Master Builder Solutions / Fosroc Chemicals / CERA CHEM / Parex Group / MAPEI Construction Products India Pvt. Ltd / CHRYSO® / Pidilite
	e. Steel bonding agents	MASTERFLOW SERIES / Master Builder Solutions / CERA CHEM / MAPEI Construction Products India Pvt. Ltd / CHRYSO® / Pidilite / Fosroc Chemicals
48	Tile Stone adhesive	MASTERFLOW SERIES / Master Builder Solutions / Roff / PIDILITE/ Fosroc Chemicals / CERA CHEM / MAPEI Construction Products India Pvt. Ltd / Roff / STP Limited / MYK Arment
P	GROUTS	
49	a. Injection grouts / Non-shrink Grouts	MASTERFLOW SERIES / Master Builder Solutions / Fosroc Chemicals / CERA CHEM / Parex Group / MAPEI Construction Products India Pvt. Ltd / CHRYSO® / UIP / Pidilite / Asian Paints / MYK
	b. Epoxy Resin Grouts	MASTERFLOW SERIES / Master Builder Solutions / Fosroc Chemicals / CERA CHEM / Parex Group / MAPEI Construction Products India Pvt. Ltd / CHRYSO® / UIP / Pidilite / Asian Paints / MYK Arment

VOLUME III APPROVED MAKES LIST- CIVIL AND ARCHITECTURAL WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
49	c. Polyester Resin Grouts -	MAPEI Construction Products India Pvt. Ltd / Fosroc Chemicals / CERA CHEM / Hilti / UIP / MYK Arment
	d. Tile/ Stone Joint Grout	MASTERFLOW SERIES / Master Builder Solutions / Pidilite/ Fosroc Chemicals / CERA CHEM / MAPEI Construction Products India Pvt. Ltd / STP Limited /
50	PU Grout	Euclid / Master Builder Solutions /FOSROC/ MYK Arment
51	Expansion Joint	Vexcolt / MM Systems / EMSEAL Joint Systems, Ltd. / CS - Construction Specialities / KANTA FLEX / MYK
52	Expansion Joint Treatment	MAPEI Construction Products India Pvt. Ltd / Master Builder Solutions / CERA CHEM / Pidilite / FOSROC / Asian Paints / KANTA FLEX / MYK Arment
53	Expansion joint sealant	MASTERSEAL / Master Builder Solutions/ CERA CHEM / FOSROC / MAPEI Construction Products India Pvt. Ltd / CHRYSO® / Pidilite / MYK Arment
54	Concrete Flooring joint sealant	MASTERSEAL / Master Builder Solutions / CERA CHEM / FOSROC / MAPEI Construction Products India Pvt. Ltd / CHRYSO® / Pidilite / MYK Arment
55	Concrete Pavement Joint Sealant	MASTERSEAL / Master Builder Solutions / FOSROC / MAPEI Construction Products India Pvt. Ltd / Pidilite
56	Construction joint product	Euclid / FOSROC / MYK Arment /Master Builder
Q	FLOORING	
57	a. Epoxy Self Smoothing System/ Coating/Toppings	MAPEI Construction Products India Pvt. Ltd / FOSROC / Master Builder Solutions / MYK Arment
	b. VDF	UCRETE & MASTERTOP / Master Builder Solutions / MAPEI Construction Products India Pvt. Ltd /
	c. IPS	CHRYSO® /BASF
58	Micro concrete.	Parex Group / Pidilite / MAPEI Construction Products India Pvt. Ltd / FOSROC
59	Testing Agencies	Civil aid technologies / Structwell / SGS Construction / Elite Engineering Consultancy
60	Bricks	As per IS 1077 of Class 3.5.
61	Soil Stabilization Polymer	Cauvery Polymers / Soilfix / Ruredil / Levostab 99
62	Plaster mesh / Corner beads / PVC cover block / Concrete	Arpitha / KNG / RAMTECH/ASTRA.
63	Thin-set mortar for Masonry	Laticrete / MYK Arment
64	Reinforcement for plaster	Recron 3S of Reliance Industries / AMAX
65	Ready-mix mortar	Ramco / Chembond
66	Ready mix plaster	Ramco / Pericon
67	Paints	Asian / Berger/ Nerolac / ICI/ Nippon
68	Acrylic Emulsion Paint	Asian / Berger/ Nerolac / ICI/ Nippon
69	Autocoat Paint	ICI – Duco / MRF
70	Putty for Internal Painting works	RJ London / NCL Alltec / Ziproc / Birla/ Asian
71	Texture Paints	SKK / Asian / Renovo / Spectrum / Armour coat
72	Cement Paint	Snowcem / Durocem /Asian
73	Clear float glass	Saint Gobain / Modi / Asahi
74	Ceramic Tiles	Kajaria / Somany / Nitco / Johnson/ RAK/ AGL
75	Vitrified Tiles	Kajaria / Somany / Nitco / Johnson / RAK/ AGL
76	PVC edge/corner bead	DURAL / Arpitha / BOSS
77	GI/ MS Pipes for Railing/ Features	TATA /JINDAL / JSW
78	Epoxy Floor coating	Roffe / Fosroc/ Ardex / MYK Arment / Master Builder

VOLUME III APPROVED MAKES LIST- CIVIL AND ARCHITECTURAL WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
79	Epoxy Grouts & Adhesives	Laticrete / Ardex Endura / MYK Arment/ Master Builder Solutions
80	Frosted glass urinal partition	Saint Gobain / Modi / Asahi
81	High Pressure Laminate urinal partition	Greenlam/Century Ply Ltd/Merino Industries Ltd
82	Solid acrylic	Corian / LG / Dupont / Hanex / Hi macs
83	Gypsum false ceiling	Saint gobain / USG boral
84	Gypsum Ceiling Suspension System	Saint gobain / USG boral
85	Gypsum ceiling system accessories	Saint gobain / USG boral
86	Laminate	Greenlam / Century Laminating Co / Merino
87	Granite Stone	As per approved sample – Gang saw cut / Water cut slab
88	Polyurethane Flooring	Flowcrete / Ardex / Silika
89	Steel Fire Doors	TATA Pravesh / Signum / Shakti Hormann / Godrej / RNB
90	Timber Doors	Kutty / Archid / Greenply
91	Hardware Fittings	Dorma / / D-line / Hafele / GEZE
92	Screws	Nettlefold / Patta screws
93	Veneer	URO / Durian / Timex / Sun / wood crest / Green-
94	Hume Pipe	Karthik Pipe/ Indian Hume pipes/ Premier spun Pipes/ Surya Precast
95	Lightweight Concrete	Hermalite / Vermiculate/Cinder
96	MS gate	Ghandhi / Hormonne / Avians / Metalcraft / Autoingress /Sri Chakra
97	Ductile Manhole Cover	Indiana / Neco
98	FRP Manhole Cover	Devi Polimer / Sintex
99	Column Guard (rubber)	Arpitha / Dural
100	PP Rungs	Arpitha /Vikrant
101	Aluminium Sections	Jindal / Indal / Bhoruka/Century
102	Expansion Joints for Tiles flooring	Dural / MYK
103	Rolling Shutter	Hormann / Ghandi/Chakra
104	Fly Ash	Dirk India, Ashechy
105	Cast in Channel	Hilty, Fisher, Halfen, Jordhal
106	Joint sealing Tape	MYK Amerete, Master Builders Solutions Pvt. Ltd., Pidilite
107	Pest Control Agency	Rentokil PCI, Godrej Pest Control, Capital Pest
108	Imidacloprid 30.5% SC Chemical	Premise SC from Bayer, Mantra TC, Imida, Lethal
109	Gypsum Plaster	Elite-100 - Gyproc Saint Gobain, Ferro – 700 Gypsum Plaster - Ferrous crete, Red Top - USG Boral
R	FAÇADE WORKS	
110	Aluminium	Jindal / Hindalco / Global Aluminium / Bhoruka
111	Reflective Glass	Saint-Gobain / Guardian / Sisecam / CS Eco
112	Clear Float Glass	Saint-Gobain / Guardian / Sisecam / CS Eco
113	Glass Processing	GlassTech / FG / Fuso / Sapphire / Sejal
114	PVB Lamination	Dupont Kurarray / Solutia / Eastman
115	SGP Lamination	Dupont Kurarray / Solutia / Eastman
116	Weather Sealant	GE Silpruf NB SCS9000 / DowSil 991
117	Structural Sealant	GE Ultraglaze SSG 440 / DowSil 983
118	ACP FR CLASS B	Viva / Aludecor / Alubond
119	High Pressure Laminate	Fundermax / Trespa / Greenlam/Century Ply Ltd/Merino Industries Ltd
120	Solid Aluminium Sheet	Novelis / Aluform

121	Automatic Sliding Doors	Dorma / Assa Abloy / Portalp
122	EPDM & Silicon Gasket	Osaka / Avigiri
123	Aluminium Coating (SDF / PVDF)	Akzonobel / Jotun / PPG
VOLUME III APPROVED MAKES LIST- CIVIL AND ARCHITECTURAL WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
124	Powder & PVDF Processer	MJ Coaters / Global Aluminium / Bhoruka
125	Open cell PU Spacer Tape	SGG Thermalbond V2200
126	Spandrel Insulation	UP Twiga
127	Fire Stop & Smoke Seal	Siderise / Hilti
128	Backer Rod	Supreme Industries
129	Patch Fitting Door & Accessories	Dorma / Saint Gobain / Hafele / Ozone
130	Mild steel	Jindal / Sail / Tata
131	Stainless Steel	Salem Steel / Sail / Jindal / Tata
132	Window hardware & accessories	GU / Giesse / Securistyle / Alualpha / As per system supplier
133	Anchors	Hilti / Fischer / Klimas / Rawlplug
134	Baffle ceiling	HunterDouglas / Equivalent
S	LANDSCAPE WORKS	
LIGHTING WORKS		
135	External Lighting Fixtures	K-Lite / Ligman / Schreder
IRRIGATION WORKS		
136	Pipes	Finolex / Supreme
137	Drip & Accessories	RAINBIRD / Xeritech / Netafim
138	Valves & Accessories	Supreme / Harit / RAINBIRD / VB / NIPL
139	Pump Accesories & Filtration	Netafim / Zoloto / Himson
140	Automation Equipments	ISI / Supreme / Finolex / RAINBIRD / PGA
NOTE 1: Contractor to proceed for procurement with preferred make, only upon approval from "PMC/Employer". Without written consent from "PMC/Employer", no procurement should be affected even if it is from the list of approved makes.		
NOTE 2: In case during the execution of the Contract, makes mentioned in the list becomes unavailable, then it will be under obligation of the bidder to execute project as per the makes approved by "PMC/Employer"		

VOLUME III APPROVED MAKES LIST – ELECTRICAL SYSTEM WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
1	HT RMG & VCB PANEL	SIEMENS/ ABB/ SCHNEIDER / MEGAWIN / LAURITZ KNUDSEN (FORMERLY L&T) AUTHORISED SYSTEM INTEGRATORS : FORMOPLASTIC CONTROLS PVT.LTD / ELECTROVAST SOLUTIONS PVT LTD./ OHM ENERGY MANAGEMENT SYSTEM PVT. LTD / SRI RAGHAVENDRA ENGINEERING SERVICES / MEGAWIN SWITCHGEARS (OR) OEM PREFERRED / AUTHORISED PANEL VENDORS ONLY
2	DISTRIBUTION TRANSFORMER WITH OLTC	VOLTAMP / ABB-HITACHI / SGB / KIRLOSKAR / CROMPTON
3	LT PANELS IEC 61439 (TTA)	SIEMENS (SIEPAN PANELS) / SCHNEIDER (BLOCKSET) / ABB (ARTUK PANEL) / LEGRAND (XL3) / RITTAL / LAURITZ KNUDSEN (FORMERLY L&T) (Ti) LIST OF OEM APPROVED SYSTEM INTEGRATORS: FORMOPLASTIC CONTROLS PVT.LTD / POWER CONTROL EQUIPMENTS PVT.LTD / UNIVERSAL POWER EQUIPMENT / ADLEC POWER PVT LTD / ELECTROVAST SOLUTIONS PVT LTD. (OR) OEM PREFERRED / AUTHORISED PANEL VENDORS ONLY
4	LT PANELS IEC 60439 (PTTA)	FORMOPLASTIC CONTROLS PVT.LTD / POWER CONTROL EQUIPMENTS PVT.LTD / UNIVERSAL POWER EQUIPMENT / ADLEC POWER PVT LTD / ELECTROVAST SOLUTIONS PVT LTD (OR) OEM PREFERRED / AUTHORISED PANEL VENDORS ONLY
5	AIR CIRCUIT BREAKERS (ACB)	SCHNEIDER / SIEMENS / LEGRAND / ABB / LAURITZ KNUDSEN (FORMERLY L&T)
6	MCCB	SCHNEIDER / SIEMENS / LEGRAND / ABB / LAURITZ KNUDSEN (FORMERLY L&T)
7	LV VFD	SIEMENS/ SCHNEIDER/ DANFOSS/ ABB/ ALLENBRADLEY / LAURITZ KNUDSEN (FORMELY L &T)
8	LV CAPACITORS&AHF	EPCOS/ SCHNEIDER/ POWERMATRIX/ NEPTUNE/ DUCATI / LAURITZ KNUDSEN (FORMERLY L&T)
9	CTS (EPOXY RESIN CAST TYPE)	PRAGATI/ ABB/ KALPA/ KAPPA/ ECS
10	VTS (EPOXY RESIN CAST TYPE)	PRAGATI/ ABB/ KALPA/ KAPPA/ ECS
11	APFC RELAY / CONTROLLER	BELUK/ CONZERV/ EPCOS/ CIRCUTOR/ HAVELLS/ NEPTUNE / LAURITZ KNUDSEN (FORMERLY L&T)
12	INDICATING METERS DIGITAL & ANALOGUE	CONZERV/ SIEMENS/ RISHABH/ SECURE/ AE
13	MULTI FUNCTION METER/AMMETER / VOLTMETER/KWH METER	SELEC/ SIEMENS/ RISHABH/ SECURE/ CONSERV
14	INDICATING LAMPS (CLUSTERED/CHIP LED TYPE)	SIEMENS/ TEKNIC/ BCH/ SCHNEIDER/ LAURITZ KNUDSEN (FORMELY L &T)
15	PUSHBUTTONS	SIEMENS/ TELEMECANIQUE/ TEKNIC/ LAURITZ KNUDSEN (FORMELY L &T) / BCH
16	HT CABLES	RPG/ UNIVERSAL/ KEI/ POLYCAB / RR KABLE
17	LT CABLES	UNIVERSAL/ RPG/ POLYCAB/ KEI / RR KABLE
18	LT CONTROL CABLES	UNIVERSAL / RPG / POLYCAB / KEI / RR KABLE
19	WIRE PVC COPPER WIRES	KEI/ FINOLEX/ LAPP/ ANCHOR/ POLYCAB / RR KABLE

VOLUME III APPROVED MAKES LIST – ELECTRICAL SYSTEM WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
20	ANNUNCIATORS	MINILEC/ ALSTOM/ ALAN/ APLAB
21	HRC FUSE	SIEMENS/ COOPER BUSSMAN/ SCHNEIDER/ LAURITZ KNUDSEN (FORMELY L &T)/ ABB
22	CONTACTORS	AC POWER CONTACTOR-SIEMENS/ ABB/ SCHNEIDER/ LAURITZ KNUDSEN(FORMELY L &T)/ ABB
23	CONTACTORS	DC POWER CONTACTOR-BCH/ BHEL/ SIEMENS
24		AUXILIARY CONTACTORS-SIEMENS/ LAURITZ KNUDSEN(FORMELY L &T)/ TELEMECANIQUE/ ABB/ SCHNEIDER ELECTRIC
25	TIME SWITCH	GIC/ THEBEN/ SIEMENS/ SCHNEIDER
26	TIMERS	SCHNEIDER/ THEBEN/ SIEMENS/ MINILEC/ LAURITZ KNUDSEN(FORMELY L &T)
27	TIME DELAY RELAY	AREVA/ ABB/ SIEMENS/ OMRON/ PLA
28	OVERLOAD RELAY	ELECTRONIC MICROPROCESSOR BASED OVERLOAD RELAY -SIEMENS/ ABB/ SCHNEIDER/ LAURITZ KNUDSEN(FORMELY L &T)
29		BI-METAL RELAYS- SIEMENS/ ABB/ SCHNEIDER/ LAURITZ KNUDSEN (FORMELY L &T)
30	CABLE GLANDS	COMET/ STOKES/ BALIGA/ DOWELLS/ 3M
31	CABLE LUGS	DOWELLS/ COMET/ SMI/ 3M/ STOKES
32	CONNECTOR	PHOENIX/ WAGO CONTROLS/ ESSEN/ CONNECTWELL
33	MCB / RCCB / RCBO / MPCB	SIEMENS/ SCHNEIDER/ ABB/ LEGRAND/ LAURITZ KNUDSEN (FORMELY L &T) /PANASONIC/HAGER
34	DISTRIBUTION BOARD	SIEMENS/ SCHNEIDER/ ABB/ LEGRAND/ LAURITZ KNUDSEN (FORMELY L &T) /PANASONIC/HAGER
35	MODULAR - SWITCHES & SOCKETS	WIPRO (ARTISA)/ LEGRAND (ARTEOR)/ PANASONIC (VISION)/ SCHNEIDER (ZENVELO)/ HAVELLS (CRABTREE)
36	METAL CLAD PLUG & SOCKETS & IP-65 PLUG & SOCKETS	LEGRAND/ SCHNEIDER/ SCAME/ CAPE ELECTRIC/ HENSEL
37	EV CHARGING SOCKETS	P2 POWER/ ABB/ LEGRAND/ DELTA /HAGER
38	PROTECTIVE RELAYS (NUMERICAL TYPE) & AUXILIARY RELAY	SIEMENS/ ALSTOM/ ABB/ SCHNEIDER
39	CONTROL / SELECTOR SWITCH	KAYCEE/ SIEMENS/ ABB/ SCHNEIDER/ LAURITZ KNUDSEN(FORMELY L &T)
40	TERMINALS	PHOENIX/ WAGO CONTROLS/ CONNECTWELL
41	CABLE JOINTING KIT/ TERMINATION KITS	RAYCHEM/ BIRLA-3M/ M-SEAL
42	CABLE TRAYS	INDIANA/ PROFAB/ CLASSIC/ TECHNOFAB/ PUSHPAK /PATNY
43	WALL / FLOOR RACEWAYS	INDIANA/ PROFAB/ OBO/ PUSHPAK/ LEGRAND
44	VOLTAGE / POWER / CURRENT / FREQUENCY / ENERGY TRANSDUCER	ABB/ SIEMENS/ AREVA
45	GI CONDUIT / PIPES/ FRLS PVC CONDUIT/MS CONDUIT	SAIL/ TATA STEEL/ BEC/ AKG/ VIP

VOLUME III APPROVED MAKES LIST – ELECTRICAL SYSTEM WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
46	INSULATING MATS	NATIONAL/ JYOTI/ DL MILLER & COMPANY/ PREMIER POLY FILM LTD/ RMG POLYVINYL INDIA LTD.
47	WINDING AND OIL TEMPERATURE INDICATOR	PRECI MEASURE/ PERFECT CONTROL/ PRAYOG
48	SINGLE PHASE PREVENTER	LAURITZ KNUDSEN (FORMELY L &T) / MINILEC/ SIEMENS
49	SMF/VRLA BATTERY	EXIDE/ AMARAJA / PANASONIC
50	BATTERY CHARGER & DCDB	CHHABI/ MASS-TECH CONTROLS/ UNIVERSAL/ HBL
51	LIGHTNING PROTECTION	OBO / DEHN / CAPE / JEF / ASHLOK
52	LIGHT FIXTURES	OUTDOOR LIGHT FIXTURES - PHILIPS/ WIPRO/ NERI/ KESELEC/ CROMPTON/BAJAJ
53		INDOOR LIGHTS PHILIPS/ REGENT / PANASONIC/ / WIPRO / HAVELLS
54		FLAME PROOF LIGHT FIXTURE- BAJAJ/ BALIGA OR EQUIVALENT
	SENSORS	PHILIPS/ REGENT / PANASONIC / WIPRO / HAVELLS / CAPE / HAGER
55	POWER PACK	MAHAMAI (MM MAX POWER)/ ALAN/ NUTEK
56	BUS DUCTS / RISING MAINS	SCHNEIDER/ LEGRAND / C&S / GODREJ / LAURITZ KNUDSEN (FORMERLY L&T)
57	CHANGE OVER SWITCH	ABB/ SCHNEIDER ELECTRIC/ SIEMENS/ HPL/ LEGRAND /ELMEASURE
58	AUTOMATIC TRANSFER SWITCH (ATS)	ASCO/ SOCOMEC/ SCHNEIDER/ ABB / ELMEASURE
59	OCCUPANCY SENSORS / DAYLIGHT SENSOR	WIPRO/ PANASONIC/ HAGER/ PHILIPS/ REGENT
60	LIGHTING POLES	WIPRO/ BAJAJ ELECTRICALS/ KESELEC/ K-LITE/ PHILIPS/ NERI
61	PLC	ALLEN BRADLEY/ SIEMENS/ ABB/ SCHNEIDER
62	EARTH LEAKAGE RELAY	PROK DVS/ ALSTOM/ SIEMENS
63	MOTORS	SIEMENS/ ABB/ KIRLOSKAR
64	SURGE ARRESTORS,SPD	CAPE/ SIEMENS/ ABB/ SCHNEIDER/ LEGRAND
65	PANEL VENTILATION FANS	RITTAL/ EBM NADI OR EQUIVALENT
66	EXTERNAL DB ENCLOSURES / POLYCARBONATE BOXES	HENSEL/ OBO/ LEGRAND/ CAPE
67	CEILING FANS (BLDC FANS)	ATOMBERG/ HAVELLS/ ORIENT/ CROMPTON/ PANASONIC/HAVELLS
68	PANEL LIGHTNING ARRESTORS	WSI/ OBLUM/ ELPRO/ CAPE
69	EARTHING	ASHLOK/ GALAXY/ CAPE/ OBO/JEF /GRAVIN
70	UPS	VERTIV/ EATON/ ABB/ RIELLO/ SOCOMEC
71	UPS BATTERY	EXIDE/ AMARA RAJA/ PANASONIC/ HITACHI
72	SOLAR PV PANEL	PANASONIC/ TATA PV SOLAR/ VIKRAM SOLAR/ WAAREE/ RENEWSYS/ EMMVEE
73	SOLAR INVERTER PANEL	SUNGROW/ BOSCH/ SIEMENS/ FIMER(ABB)/ HAVELLS
74	DIESEL GENERATOR SET WITH ACCOUSTIC ENCLOSURE	ENGINE - CUMMINS / MTU/ CATERPILLAR /BAUDOUIN ALTERNATOR -STAMFORD/ LEROY SOMER/ AVKC
75	BALL VALVES	LEADER/ AUDCO/ BDK/ INTERVALVE

VOLUME III APPROVED MAKES LIST – ELECTRICAL SYSTEM WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
76	CS/GI PIPES	JINDAL/ PRAKASH/ ZENITH/ TATA STEEL
77	SEAMLESS CS PIPES	TATA STEEL/ MAHARASHTRA SEAMLESS/ KALYANI STEEL/ IMPORTED
78	CS/GI FITTINGS AND FLANGES	ALLIANCE FORGE/ TUBE PRODUCTS INCORPORATE/ SIVANANDA/ EBY INDUSTRIES/ TEEKAY TUBES,MUMBAI
79	STEEL PLATES	JINDAL/ TATA STEEL/ SAIL
80	GASKETS	GASKETS INDIA PVT. LTD/ IGP ENGG. LTD/ MECHANICAL PACKING INDUSTRIES
81	PAINTS	BERGER/ NEROLAC/ ASIAN PAINTS
82	LEVEL SWITCH	PUNE TECHTROL/ CHEMTROLS ENGG. LTD./ LEVCON/ SBEM
83	LEVEL GAUGE	PUNE TECHTROL/ CHEMTROLS ENGG. LTD./ LEVCON/ SBEM
84	SIMPLEX FILTERS	MAHLE/ HONEYWELL
85	VIBRATION ISOLATION	CUSHY FOOT MOUNTS/ DUNLOP/ GERB
86	STRUCTURAL STEEL	SAIL/ TATA STEEL
87	LIFTS	OTIS/ JOHNSON/ KONE/ SCHINDLER
88	PANEL FIRE PROTECTION / SUPPRESSION SYSTEM	FIRE TRACE / ROTAREX / CEASEFIRE / KANEX - REFER FIRE PROTECTION APPROVED MAKELIST
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VOLUME III APPROVED MAKES LIST – HVAC SYSTEM WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
A	HVAC SYSTEM	
1	Air Cooled Chillers	Trane/York/Daikin/Climaventa/Carrier
2	Water Cooled Chillers / CPM / Auto Tube Cleaning System	Trane/York/Daikin/Carrier/Kirloskar
3	Chilled water pumps	Xylem/Grundfos/Armstrong
4	Cooling tower	Advance/Marley/Bell/Paharpur
5	Chemical Dosing System	IONExchange/Nalco
6	Air Handling Units / Ceiling Suspended Units / Treated Fresh Air Units	Zeco/Systemair/Edgetech/Citizen/Flaktwood
7	Heat Recovery Wheel	Ostberg/Dryair-Pahwa/Munters
8	Fan Coil Units	Caryaire/Zeco/Edgetech/Systemair
9	Chilled water cassette Units	Carrier/Midea/Daikin
10	Precision Air Handling Units	Stulz/Vertiv/Schneider/Climaveneta
11	EC Fans	ZiehlAbegg/EBMPapst
12	VRF	Daikin/Toshiba/Mitsubishi
13	Filters	AAF/Thermadyne/Spectrum/Freudenberg/Camfil
14	Axial / Cabinet Ventilation Fans	Kruger/Greenheck/Nicotra/Systemair
15	Two Stage Air Washer	HMX/Edgetech/Humidin
16	Variable Frequency Drives	Danfoss/ABB/Siemens/Schnieder
17	MS Pipes	Jindal/Tata/SAIL
18	Copper pipes	Mandev/Nippon/Totalline/Rajco
19	Butterfly Valves	Audco/Advance/Sant/Utam
20	Ball Valve	Audco/Kitz/Leader/Zoloto
21	Check valve	Advance/Audco/Leader/Zoloto
22	Flow Control Valves ((Pressure Independent type))	Danfoss/Siemens/Honeywell/Belimo/Flowcon
23	2-Way Modulating & On / Off Valves	Danfoss/Siemens/Honeywell/Belimo/Flowcon
24	Automatic Balancing Valves	Advance/Audco/Leader/Zoloto
25	Y-Strainer / Pot Strainer	D.S.Engineering/Sant/Advance/Emerald
26	Suction Guide	Xylem/Grundfos/Armstrong
27	Pressure & Temperature Gauges	Wika/Dwyer/Baumer/H-guru
28	Pipe Insulation – Nitrile Rubber	Armaflex/KFlex/Aeroflex
29	Underdeck Insulation	Beardsell/UPTwiga
30	Auto Airvent	Amtrol/Flamco/Anergy
31	Pressurized Expansion Tank	Anergy/Armstrong/Grundfos/Flamco
32	Air separator	Anergy/Armstrong/Grundfos/Flamco
33	VAV Box	Trox/Honeywell/Siemens/Cosmos
34	Dry scrubber	Trion/Rydair/Espair
35	Galvanized Steel Sheet	TATA/Jindal/SAIL
36	Duct Insulation – Nitrile Rubber	Armaflex/KFlex/Aeroflex
37	Fibre glass	UPTwiga/Owens'scorning
38	Air Terminal / Distribution Devices - Grilles, Diffusers, Dampers & Louvers	Caryaire/Systemair/Cosmos/Ruskin-titus/Unitile
39	Insulated Flexible Ducting	Caryaire/Atco/UPTwiga
40	Motorized Smoke & Fire damper	Greenheck/Ruskin/Caryaire/Systemair
41	Actuators	Belimo/Siemens/Honeywell
42	Drainpipe	Supreme/Astral/Prince
43	BTU Meter	Kamstrup/Landys-gyr/KrohneMarshal/Siemens
44	Fire Sealant	3M/ Hilti
45	Vibration Isolator / Flexible Bellow	KanwallIndustries/Resistoflex/Easyflex
46	Wire Support	Hilti/3M/Gripple

VOLUME III APPROVED MAKES LIST – HVAC SYSTEM WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
A	HVAC SYSTEM	
47	Air Curtain	Systemaire/VTs/Euronics
NOTE 1: Contractor to proceed for procurement with preferred make, only upon approval from "PMC/Employer". Without written consent from "PMC/Employer", no procurement should be affected even if it is from the list of approved makes.		
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NOTE 3: For cables, motors & cable tray specification and approved make refer Electrical Make List		
NOTE 4: For BMS related Items refer IBMS Specification and approved make list.		

VOLUME III APPROVED MAKES LIST – FIRE PROTECTION SYSTEM WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
A	FIRE PROTECTION SYSTEM	
1	Fire water Main, Jockey & Booster pump set – Hydrant system, Sprinkler system, Water curtain system.	Kirloskar/ Wilo - Mather Platt / Xylem / Grundfoss/ Armstrong / Ebara
2	Electrical Motor	ABB/ Bharat Bijlee/ Kirloskar Electric Co./ Siemens India Ltd/ Crompton Greaves Ltd
3	Diesel engine	Cummins/ Greaves/ KOEL/ CATERPILLAR
4	Battery	As per tender approved make list of Electrical Installations.
5	Thermal insulation for exhaust pipe	UP Twiga/ Lloyd Insulation/ Owens Corning/ Kimmco
6	G.I , M.S. Pipes	SAIL/Tata/Jindalhissar/ Apollo
7	G.I , M.S. Fittings	UNCO/ UNIK/ NEW/ HB/ Bharat Forge
8	Underground pipe protection wrap	Pypcote/ Tapex/ Rustfire
9	Ductile Iron pipes	Electrosteel/ Neco/ Lanco/ Kapilansh
10	Anchor Fastener, Clamps, Pipe hangers support	Hilti/Fisher/Easyflex/Hi tech/Diamond
11	Welding Rods	Advani/L&T/ESAB/ Marglam/ Ador/ cosmos/ Super Bond(S)
12	Structural steel	Tata/ SAIL/ Jindal Hissar/ Apollo
13	Sluice Valves	Lehry / SANT / Advance / Audco / Zoloto
14	Butterfly (manual, gear operated) Valves	Lehry / SANT / Advance / Audco / Zoloto
15	Non Return Valves	Lehry / SANT / Advance / Audco / Zoloto
16	Tamper switch for Butterfly Valve	Honeywell/ Potter/ Rapid Control/ System Sensor/Pacific Fire
17	Ball Valves	Lehry / SANT / Advance / Audco / Zoloto
18	Globe Valve	Lehry / SANT / Advance / Audco / Zoloto
19	Foot valve with strainer	Kirloskar/ Normex/ Kartar
20	Air Release Valve	Lehry / SANT / Advance / Audco / Zoloto/Cla-Val
21	Y-type Strainer	Lehry / SANT / Advance / Audco / Zoloto
22	Air vessel	Nema/ Zenith/ Equivalent
23	Pressure Relief Valve	Newage/Cla-Val/ Tyco/ Viking
24	Pressure Switch	Danfoss/ Indfoss/ Viking/ Delta Control
25	Pressure Gauge	Feibig/H.Guru/Emerald/Waaree
26	Flow Test Meter	Viking/ Newage/Global Vision/ Eureka Forbes / Fabri-Tek Equipments Pvt Ltd./ Gerand
27	Hydrant Valve, Branch pipe with nozzle	Newage (Mumbai)/ Safex/ Minimax/ Eversafe/ Shah Bhogilal/Newage (Surendranagar)
28	Hose Coupling	Newage (Mumbai)/ Safex/ Minimax/ Eversafe/ Shah Bhogilal/Newage (Surendranagar)
29	RRL Hose Pipe	Newage (Mumbai)/ Safex/ Minimax/ Eversafe/ Shah Bhogilal/Newage (Surendranagar)
30	Fire aid Hose reel with drum	Newage (Mumbai)/ Safex/ Minimax/ Eversafe/ Shah Bhogilal/Newage (Surendranagar)
31	Fire Hose cabinet - External , Internal, Fireman Axe	Newage (Mumbai)/ Safex/ Minimax/ Eversafe/ Shah Bhogilal/Newage (Surendranagar)
32	Fire brigade connection(Inlet & Draw out)	Newage (Mumbai)/ Safex/ Minimax/ Eversafe/ Shah Bhogilal/Newage (Surendranagar)
33	Alarm Control Valve , Installation Control Valve	Tyco/ HD /Newage (Mumbai)/ Newage (Surendranagar)/Viking
34	Pressure Reducing Valve (PRV)	Zoloto/ sant/ Watts/ UTAM/ Honeywell/ Lehry
35	Zone Control Valve(ZCV)	Tyco/ Viking/ HD Fire/ Reliable

VOLUME III APPROVED MAKES LIST – FIRE PROTECTION SYSTEM WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
36	Sprinklers (UL listed only)	HD Fire/ Tyco/ NewAge (Mumbai)/ NewAge (Surendranagar)/ Reliable/ Viking.
37	Sprinkler flexible pipe (UL listed only)	HD Fire/ Tyco/ Safex/ NewAge (Mumbai)/ NewAge (Surendranagar)
38	Sprinkler annunciation panel	Minilec/ Alan/ PCD Linovate Global/ Agni Fire/ AES
39	Power cables	As per tender approved make list of Electrical Installations.
40	Control cables - armoured, unarmoured, FRLS	As per tender approved make list of Electrical Installations.
41	Cable Tray	As per tender approved make list of Electrical Installations.
42	Fire Extinguishers	Safex/ Minimax/ Novel/ Kanex/ Ceasefire
43	Water flow switch	Honeywell/ Johnson Controls/ Siemens/ System Sensor/Switzer/ Plotter
44	Paint, Primer	Asian Paint/ Nerolac / Berger/ Nippon
45	Anti-Vibrating Mounting pads, Expansion Joints	Dulop/ Resistoflex / Easy flex/ Flexionics/ Vimpa
46	Fire Fighting Panel & accessories	As per tender approved make list of Electrical Installations.
47	Local Starter Panel & accessories	As per tender approved make list of Electrical Installations.
48	Fire sealant / Mortar	3 M India Ltd. / Hilti / Promat
B	FIRE SUPPRESSION SYSTEM	
49	Clean Agent Gas Based Fire Suppression System	UTC Fire & Security (Kidde)/Sevo/ Tyco (Johnson Controls)/Viking/ Minimax/Siemens/Honeywel/Rotarex
50	FK-5-1-12 or equivalent Gas cylinder filled listed and CCOE approved (seamless cylinders duly approved by PESO,CCOE).	3m corpora/ honeywell/siemens/sevo/ Viking minimax (german)
51	Electrical actuator	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
52	Manual actuator	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
53	Pneumatic actuator	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
54	Discharge hoses	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
55	Actuation hoses	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
56	Manifold check valves	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
57	Nozzles	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
58	Low pressure switch	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
59	Nitrogen pilot cylinder and valve assembly & pressure gauge	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
60	Discharge pressure switch	Ansul/ Tyco/ UTC/ Siemens/ Honeywell/ Sevo/ Viking/ Minimax/Rotarex
61	Seamless Pipes for clean agent	Indian seamless / maharashtra seamless/ tata

VOLUME III APPROVED MAKES LIST – FIRE PROTECTION SYSTEM WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
62	gas release panel, with programmable relay modules& built-in listed power supply	Notifier / fenwal / simplex / synergy/hochiki/ honeywell/ bosh/ ravel
63	Dual action manual release station	Notifier / fenwal / simplex / synergy/hochiki/ honeywell/ bosh/ ravel
64	Deadman type abort switch	Notifier / fenwal / simplex / synergy/hochiki/ honeywell/ bosh/ ravel
65	Circuit integrity cables for fire alarm , voice evacuation , suppression , hssd;	Polycab / Varsha Cables / RR Kable/ Deepanchan / Havells
66	Lugs & Glands	As per tender approved make list of Electrical Installations.
C	MISCELLEANOUS	
67	Chain Block pulley with Trolley	Hercules Mechanical works Cranedge India Pvt Ltd /MorrisIndef / RMS Industries
68	Panel Fire Protection / Suppression System	Fire Trace / Rotarex / Ceasefire / Kanex
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VOLUME III APPROVED MAKES LIST – PLUMBING WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
A	Plumbing Works	
1	Ball Valves	Zoloto/ Sant/ Hawa/ Honeywell/ Lehry
2	Globe Valve	SANT/ Zoloto/ Hawa/ CIM/ Lehry
3	Gate Valve	SANT/ Zoloto/ Leader/ Kirloskar/Lehry
4	Sluice Valves	SANT/ Zoloto/ Leader/ Kirloskar/ Audco (L&T)
5	Butterfly Valve	Audco/ Advance/ Zoloto/ Sant/ Lehry/ Honeywell
6	Non Return Valve / Check valve (All type)	Audco/ Advance/ Zoloto/ Sant/ Lehry/ Honeywell
7	Motorized Butterfly Valves	Honeywell/ Belimo/ Siemens/ Johnson controls/ Kitz
8	Pressure Reducing Valves	Zoloto/ sant/ Watts/ UTAM/ Honeywell/ Lehry
9	Air Release Valve	Zoloto/ sant/ Watts/ Studor
10	Air Admittance Valve	Gebrit/ Studor/ Ashirvad / Astral
11	Ball Type Non Return Valve for Sewage Application	Lehry/Leader/ Sant/ Danfoss/ Silverspark/ Zoloto
12	Solenoid Valve	Honeywell/ Johnson Control/ Avcon/ Aira/ Danfoss/ Lehry
13	Float Valve	CSA Atena/ Esseti/ Leader/ Lehry/ Sant
14	Copper Pipes	Fastwell engineering/ Mexflow/ Flowflex - Rajco/ Viega/ Sk metals
15	Copper pipe fittings	B Press/ Yorkshire/ Nibcop
16	Stainless Steel Pipe	EQ SS/ J Press/ Sanghavi
17	Stainless Steel Pipe Fittings	EQ SS/ J Press/ Sanghavi
18	G.I . Pipes	SAIL/Tata/Jindalhissar
19	G.I fittings	UNCO/ UNIK/ NEW/ HB/ Bharat Forge
20	CI/DI pipe & Fitting	Electrosteel - Lanco/ Neco/ Kapilansh/ Kartar valve & fitting/ SKF C.I pipe
21	Hubless Cast Iron Pipes and Fittings	Neco/ Kapilansh / Raj patterns makers and founders/ SKF C.I pipe
22	Cast Iron LA Pipes and Fittings	Electrosteel - Lanco/ Neco/ Kapilansh/ Kartar valve & fitting/ / Raj patterns makers and founders/ SKF C.I pipe
23	uPVC & cPVC -water supply pipes and fittings	Finolex/Prince/Supreme/Ashirwad/Astral
24	RCC Pipes - IS :458	Indian Hume pipe/ Pranali/ Southern concrete
25	Hot/Cold Water Pipe Insulation	Armacell / K- Flex/ A-Flex/ ALP aeroflex/ Thermaflex
26	Level controller & Indicator	Auto Pump/ Cirrus/ Engineering/ Technika/ Pumptrol/ Pune Techtrol/ Lehry
27	Water flow switch	Honeywell/ Johnson Control/ Seimens/ Viking-Potter
28	Actuators	Rexroth/ Avcon/ Honeywell/ Billimo/ Lehry
29	Pressure Gauge	Feibig/ H.Guru/ Emerald/ Waaree/ Wika
30	Grease Trap	ACO/ Kessel/ Wade/ MIFAB
31	Y – Strainer	Zoloto/ Honeywell/ Emerald/ Sant / VTM
32	Dismantling Joint	Viking Johnson/ Anant Engg./ Victaulic
33	Flexible Joint/ Rubber Bellows	Resistoflex/ Kanwal(Easyflex)/ Cori / Flexionics/ Vimpa
34	Anti Vibrating Mounting	Resistoflex/ Kanwal(Easyflex)/ Cori / Flexionics/ Vimpa
35	G.I/ MS pipe protection wrapping and coating	IWL- Pypkote/ Rustech-Coatek/ Neotape/ STP Ltd.
36	C.I pipe Joint	Acqua Bond/ Drip Seal/ Mega Seal
37	G.I pipe sealent	Henkel-Loctite 55/ Holdtite
38	Water Meters	Deshmesh/ Aquamet Zenner/ Rockwin /Lehry
39	Electric Water Heater	A.O.Smith/ Venus/ Racold/ Jaquar

VOLUME III APPROVED MAKES LIST – PLUMBING WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
40	Rain Water Outlet/ Scupper drain	ACO/ Neer/ GMGR/ Kessel/ MIFAB/ Chilly
41	FRP/SFRC Manhole Frame,cover & grating	Thermo Drains / Prolong Composite / Everlast / Fibrocast
42	Polymer concrete drain channel (SS grating, slotted grating)	ACO/ Kessel/ MEA/ MIFAB
43	Floor Clean out plug/ clean out plug/ Floor Trap/Floor drain/ Cockroach Trap	Chilly/ ACO/ Neer/ GMGR/ Kessel/ MEA/ Geberit/ MIFAB
44	Submersible Pump (Sewage/ De-watering/ Water Supply)	Grundfoss/ WILO/ Xylem (FLYGT)/ EBARA/ / Kirloskar
45	Hydropneumatic Pumps	Grundfoss / Xylem (Lowara)/ WILO/ EBARA
46	Water Transfer / Booster Pumps	Grundfoss / Xylem (Lowara) WILO/ EBARA
47	Macerator pumps (Solo lift pumps)	Grundfos / Equivalent
48	Motors	ABB/ Siemens/ CGL/ BBL
49	Anchor Fastener / Clamps / pipe hangers/Support	Hilti/Fisher/Easyflex/Hi tech/Diamond
50	Fire Sealant	Hilti/ Birla 3 M/ Promat
51	Paint	Asian Paint/ Nerolac / Berger / Nippon
52	Grease separator	ACO/ Kessel/ Wade/ MIFAB
53	Lifting pump for Oil separator	Kessel/ ACO/ Kirloskar/ Grundfos/ KSB/ MIFAB/ WAD
54	Over Head Tanks	Sintex/ ATUL/ Fusion
55	PVC/uPVC SWR/Agri- Drainage pipes	Finolex/Prince/Supreme/Ashirwad/Astral
56	Gully trap (stone ware)-IS 651	Perfect/ Rajura/TACEL/Mysore Stoneware pipe OR I. S. I. MARKED
57	Foot rest / rungs	OM plastic/ KGM
58	Welding rods	Advani/L&T/ESAB/ Marglam/ Ador/ cosmos/ Super Bond(S)
59	MS Structural support	Tata/ SAIL/ Jindal Hissar/ Apollo
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VOLUME III APPROVED MAKES LIST – SEWAGE TREATMENT PLANT		
S. NO	ITEM	APPROVED MAKES / VENDORS
1	Manual Screens	Proprietary
2	Centrifugal Pumps	Mather & Platt / Becon /GRUNDFOS / Kirloskar / KSB
3	Submersible Pumps	Grundfos / Xylem / Wilo / Ebara/ Pullen
4	Slotted pipe oil skimmer	Proprietary
5	Sludge Pumps	Johnson / Wilo / Ebara / Grundfos
6	MBR Modules	Suez / Hydronautics/ Koch Membrane/ Mitsubishi
7	Drum Screen	Auric / Huber / Jash
8	Air Blower	Kay international /Everest/Usha compressor/Aerzen / Ingersol Rand / TMVT
9	Mixer	Wilo / Grundfos / Xylem
10	Coarse Bubble Air Grid (Equalisation Tank/Sludge Holding Tank)	Proprietary
11	Fine Bubble Air Diffusers (Aeration Tank / MBR Tank)	OTT/Rehau/Titan/ Southern Cogen
12	UF membrane	Qua/Hitech/ Toray/ Hydranautics/ DuPont
13	RO membrane	Hydranautics/ DuPont/ Toray/ LG/ Koch
14	Clear Water Pumps & HSCF Pumps	Grundfos / Xylem / Suzler/ Kirloskar
15	Decanter Centrifuge	Alfa Level / Hiller / Humbolt
16	Dosing Tank	Sintex/ Sharp / Polyplast/ Supreme/ National
17	Dosing Pumps	Milton Roy /Prominent/Toshcon/ Emec Italy
18	MSEP Filter Vessel	OEM Fabricated
19	F.R.P Pressure Vessel	Pentair / Structural / Equivalent Fabricated
20	Mechanical Seal	Burgmann / Sealol / Eqvt
21	Anti Vibration Mounting	Kanwal / Dunlop / Resistoflex
22	Pressure Gauge	Waree / H.Guru/ Baumer/ Ashcroft/ Wika
23	Water Meter (Mechanical Type)	Actaris . Capstan – Woltman / Kranti
24	Electromagnetic Flow Meter	Emerson / E&H / Siemens / Jumo/ Forbes Marshall
25	Pressure Transmitter	Siemens/ Emerson/ E&H/ Jumo
26	DO Transmitter	Emerson /ABB /E&H /Hach/ Danfoss/ Yokogawa
27	pH Analyser	Forbes Marshall / E&H / Hach
28	Turbidity Transmitter	Emerson/ABB/E&H/Hach
29	Level Switch	Pune Techtrol/ Nolta / Jumo
30	Level Sensor& Indicator	ABB/ Bells Controls/ Forbes Marshal/ Pune Techtrol/ Level tech/ Elegant
31	Level Indicator	Levcon/ Pune Techtrol/ cirrus
32	Paints	Asian Paints / Berger / ICI/ Apex
33	Mechanical Screen	Ovivo / Aquaseptence / Jash / Auric
34	Air Flow Rotameter	Eureka Industrial Equipments / Aster / Tansa
35	GI/MS/SS Pipes (IS: 1239 and IS : 3589)	Tata / Jindal/ SAIL
36	GI / MS/SS Pipe fittings	Pot/Unik / Zoloto M
37	PVC Pipe Sch 80, Sch 40	Astral/Ashirvad/Supreme/Prince
38	GM / Forged Brass Ball Valves	Zoloto / Intervolve / Audco
39	Sluice Valves	Kirlosakar/Ivc/Sant/ Zoloto/ Leader/ Audco
40	Butterfly Valve	Audco / Intervolve / Bray
41	Motorised Butterfly valves	Honeywell/ Johnson control/ Siemens/Belimo
42	Wafer Type Check Valve	Advance / Intervolve / Bray
43	Multiport Valve	Pharer (U.S.A)/ Flack (U.S.A) / Initiative / Aventura
44	Isolation Ball / Gate / Globe Valve	Zoloto/ Sant/ Hawa /Honeywell/ Lehry

VOLUME III APPROVED MAKES LIST – SEWAGE TREATMENT PLANT		
S. NO	ITEM	APPROVED MAKES / VENDORS
45	Air Release Valve	Zoloto/ Sant/ Watts/ Studor
46	Pressure Reducing Valves	Zoloto/ Sant/ Watts/ UTAM/ Honeywell, Lehry
47	Float Valve	CSA Atena/ Esseti/ Leader/ Lehry/ Sant
48	Ball Type Non Return Valve for Sew	Leader/ Sant/ Danfoss/ Silverspark/ Zoloto
49	Solenoid Valve (SOV)	Avcon Controls / Dembla Valves / Rotex Automation
50	Non Return Valve (Reflux Valve/Check Valve)	IVC/R&D Multiples/HAWA/Kirloskar
51	Ductile Iron pipe & Fittings	Jindal/Electrotherm/Rashmi/Electrosteel/TATA Mitaliks
52	Expansion Bellow	Percise Engineers/ B.D Engineers
53	Electrical Actuators Valves	Cair / Jonson / Auma / Honeywell
54	Y Strainer	Zoloto/ Honeywell/ Emerald/ Sant / Vtm
55	HDPE Pipe	Noble / Reliance.
56	Agitator	Remi / Fluidyme
57	Air Compressor	Ingersol Rand / ELGI
58	Anchor Fasteners	Hilti/ Fisher/ Easy flex/ Hi tech/ Diamond
59	Bolts & Nuts	Ashcroft India Pvt. Ltd / Fasteners & allied Products Pvt. Ltd / Hardwin Fasteners Pvt. Ltd. Multi Fasteners Pvt.Ltd / Sundaram Fasteners Pacific forging & fasteners Pvt. Ltd / Boltmaster (india) Pvt. Ltd.
60	Gaskets	Packings & jointings gaskets Pvt. Ltd / Spiraseal gaskets Private Ltd / Teekay Metaflex Pvt. Ltd. / Goodrich gasket Pvt Ltd / IGP Engineers Pvt Ltd
61	LT Power Distribution Panels (TTA) Totally Type Tested (As per IEC-61439 - 1 & 2)	Siemens, Schnieder, ABB, L&T, Legrand (Approved OEM Vendors only)
62	LT Power Distribution Panels (Non TTA)	Project specific Authorized / Approved OEM Vendors only
63	Starter, Contactor, Push Button	Schneider /L&T / GE / Siemens /ABB
64	MCCB's	Schneider/ Siemens/ L&T/ Legrand/ ABB/ Hager
65	MCB/RCCB / SPD/RCBO /and all other accessories	Legrand/ Schneider/ Hager/ L&T
66	Overload relays with built-in Single-Phase Preventer	Schneider /L&T / GE / Siemens /ABB
67	Current Transformer (Cast Resin Epoxy Coated)	Automatic Electric/ Gilbert & Maxwell/ Kappa/ Pragati/
68	Protection Relay Numeric Type	Alstom / ABB / Siemens / L & T
69	Protection Relay Electromagnetic	Alstom / EasunReyrolle
70	Rotary Switch	Siemens / GE / Larsen & Toubro
71	Timer Delay Relay	Siemens / GE / L&T/ Bhartia
72	Timer	Schneider/ Siemens/ L&T/ ABB / Theben/ Legrand
73	Selector Switches (ASS/VSS)	ABB/ Siemens/ Schneider/ L&T/ Salzer
74	On Load Change over switch / Switch Fuse Units	L&T/ Siemens/ ABB/ Schenider/ Havells/ HPL/ C&S
75	Ammeter and Voltmeter	Rishabh (L& T)/ Automatic Electric
76	Electronic Digital Meter (A/V/PF/HZ/KWH) , with LED Display.	Schneider (Conserv)/ Elmeasure. Legrand/ L&T
77	Static Power Meter & Logger (SPML)	Conzerv/ JMP/ AE
78	Indicating Lamps	L&T/ Siemens/ Schneider/ ABB/ RASS control

VOLUME III APPROVED MAKES LIST – SEWAGE TREATMENT PLANT		
S. NO	ITEM	APPROVED MAKES / VENDORS
79	Push Buttons	ABB/ L&T/ Schneider/
80	Power cables 1100V grade	Universal/ Finolex/ Polycab/ KEI/ Havells/ Ravin cables
81	Copper Conductor PVC Insulated Wires/ Stranded Flexible Wires	Finolex/ RR Kabel/ Havells/ Polycab/ Lapp India/ Ravin Cable. [FRLS type]
82	Limit Switches	Siemens / BCH / Jai Balaji /L&T
83	Terminals	Elmex / Connectwell / Wago / Phoenix
84	MS Black Stove Enameled ERW Conduits(ISI Approved) and its accessories	AKG/ BEC/ Steelkraft
85	PVC Conduit (FRLS) & Accessories (ISI Approved)	Precision/ BEC/ Nihir / AKG
86	Cable Trays and its supports and accessories	OBO/ Indiana/ Legrand
87	Online Monitoring	Pratham Enviro/Seimens/Hach/Potence Controls
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VOLUME III APPROVED MAKES LIST – SOLID WASTE MANAGEMENT		
S. NO	ITEM	APPROVED MAKES / VENDORS
1	Mechanized Composting (In vessel Composting)	Nachiket Engineering Pvt. Ltd. Pune Pratham Envirotech Solutions, Mumbai. ECOBOT Wet Waste Converter System. Cinetico Technology Pvt. Ltd.
2	Garbage Dust Bins	Otto Waste Systems, Sheetal Industries, Aristoplast product Pvt. Ltd. Neelkamal, Sintex Plastics Technology Pvt. Ltd
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NOTE 2: In case during the execution of the Contract, makes mentioned in the list becomes unavailable, then it will be under obligation of the bidder to execute project as per the makes approved by "PMC/Employer"		

VOLUME III APPROVED MAKES LIST - ELV SYSTEM		
S. NO	ITEM	APPROVED MAKES / VENDORS
A	INTEGRATED BUILDING MANAGEMENT SYSTEM	
1	BMS Server	DELL / HP / IBM
2	Operator Workstation	DELL / HP / IBM
3	BMS Head-End Software	Honeywell - Trend IQ Vision / Honeywell - EBI / Johnson Controls - Metasys / Siemens - Desigo CC / Schneider - Ecostructure / Delta Controls - Enteliweb
4	IP DDC Controllers	Honeywell - Trend IQ4E / Honeywell - Comfort Point / Johnson Controls - Metasys / Siemens - Desigo / Schneider - Ecostructure / Delta Controls - Enteliweb
5	Soft Integration / 3rd Party Integration Unit	Honeywell - Trend IQ4E / Honeywell - Comfort Point / Johnson Controls - Metasys / Siemens - Desigo / Schneider - Ecostructure / Delta Controls - Enteliweb
6	Temperature Sensor / Room Type Thermostat / Immersion Temperature Sensor with Thermowell / Pressure Sensor (Water & Air) / Differential Pressure Switch (Water & Air) / Room Type Temperature & RH Sensors	Dywer / Greystone / Honeywell / Johnson Controls / Siemens / Schneider
7	Indoor Air Quality Sensor / Differential Pressure Transmitter (Water & Air) / Ambient Temperature & RH Sensor / Co2 Sensor (Ambient type / Duct Mount / Wall Mount)	Dywer / Greystone / Honeywell / Johnson Controls / Siemens / Schneider
8	Water Level Switches & Level Transmitter	Filpro / Techtrol / Levecon / Sontay / Kele
9	DDC Controller Enclosures Box (Indoor Type IP55 & Outdoor Type IP66)	Arrow Engineers / Power Control Engineering / Rittal / Shrinath Enterprises / Zenith Engineering
10	Hydrogen Sensor for Battery Room	Ambetronics / Dywer / Greystone / Honeywell / Kele
11	Air Velocity Sensor (Multi Probe & Multi Point)	Greystone / Kele / Sontay / TSI - USA
12	Water Hardness Analyser	Forbes Marshall / Hach / Lumex / Polymetron / Thermo
13	P.H / Chlorine Analyser	Forbes Marshall / Hach / Lumex / Polymetron / Thermo
14	TDS & DO Sensor	Forbes Marshall / Hach / Lumex / Polymetron / Thermo
15	Communication Cables / Signal Cables / Control Cables / Power - Cables	Lapp Cables / Belden Cables / Technoflex Cables / KEI International / Havells Cables
16	Network Colour Printer	Cannon / Epson / HP
B	FIRE ALARM SYSTEM	
17	Fire Alarm Panel / Network Repeater Panel / BMS Integration Module (BACNet / Modbus)	Honeywell - Notifier / Honeywell - XLS 3000 / Edwards - EST4 / Tyco - Simplex / Siemens - Cerberus (UL Listed)

VOLUME III APPROVED MAKES LIST - ELV SYSTEM		
S. NO	ITEM	APPROVED MAKES / VENDORS
18	Multi-Sensor Detectors / Rate of Rise of Heat Detectors / Beam Detectors / Duct Detectors	Honeywell - Notifier / Honeywell - XLS 3000 / Edwards - EST4 / Tyco - Simplex / Siemens - Cerberus (UL Listed)
19	Manual Call Point / Control Relay Module / Input - Monitor Module / Isolator Module	Honeywell - Notifier / Honeywell - XLS 3000 / Edwards - EST4 / Tyco - Simplex / Siemens - Cerberus (UL Listed)
20	Response Indicator	Honeywell - Notifier / Honeywell - XLS 3000 / Edwards - EST4 / Tyco - Simplex / Siemens - Cerberus (UL Listed)
21	Batter Backup for Fire Alarm Panel & 24VDC Hooter Power supply Unit	Exide / Amaron / Panasonic
22	Power Supply Unit with Battery Charger and Enclosure	Sanstar / C-System / Briotronix / C-Tec
23	Graphical User Interface Software	Honeywell - Notifier / Honeywell - XLS 3000 / Edwards - EST4 / Tyco - Simplex / Siemens - Cerberus (UL Listed)
24	Graphical User Interface Software Workstation	DELL / HP / IBM
25	2Core 1.5Sq.mm Copper Armoured FRLS Cable for Fire Alarm & Public Address System	Polycab / Varsha Cables / RR Kable / Deepanchan / Havells
26	Aspiration Smoke Detection (ASD) Panel and Power Supply Unit / Cabilary Tubes	Honeywell - Xtralis / Securiton / Edwards / Siemens
27	CPVC Pipes and its Accessories	As per ASD OEM Recommendations
28	Rodent Repellent & Water Leak Detection System	C-System / Star Electronics / Maser / Briotronix / Sontay
C	DIGITAL PUBLIC ADDRESS SYSTEM	
29	Loud Speakers	TSG - Crome / Bosch - Paviro / Honeywell - Variodyn / Atlas - IED / Tonmay / Ateis - IDA8
30	Digital Voice Alarm Controller	TSG - Crome / Bosch - Paviro / Honeywell - Variodyn / Atlas - IED / Lap Gruppen / Ateis - IDA8
31	Class-D Power Aplifier	TSG - Crome / Bosch - Paviro / Honeywell - Variodyn / Atlas - IED / Lap Gruppen / Ateis - IDA8
32	MP3 Media Player	Philips / Sony / LG / Samsung / TSG
33	2Core 1.5Sq.mm Copper Armoured FRLS Cable for Fire Alarm & Public Address System	Polycab / Varsha Cables / RR Kable / Deepanchan / Havells
D	SECURITY ACCESS CONTROL & PHYSICAL SECURITY SYSTEM	
34	Access Control System Controller and Reader Module (OSDP Protocol)	Honeywell / Tyco / HID / Gallagher / Rosslare
35	Access Control Software	HID - SSI / Tyco - Kantech / HID - IDCube / Gallagher / Rosslare
36	Customer Relationship Portal Way Finding Application Kiosk and IP Smart Signage Display	Application Software: Sublime / LG / Visix / Poppolo Display Panel: Samsung / LG / Delta / Sharp
37	Smart Card Reader (iClass & Mifare compatible)	HID / Gallagher / Tyco / Honeywell / Rosslare
38	Biometric (Finger-Print) Reader	Suprema / Virdi / Idemia / HID / Gallagher / Rosslare
39	QR-Code Reader	IDCube / SSI / Electron / Magtech / Rosslare
40	iClass & Mifare Access Cards	HID / Gallagher / Rosslare

VOLUME III APPROVED MAKES LIST - ELV SYSTEM		
S. NO	ITEM	APPROVED MAKES / VENDORS
41	Electro Magnetic Lock (Single Leaf & Double Leaf)	Bel / Trimec / Ebelco / Assa Abloy / Rosslare
42	Door Position Sensor / Magnetic Contact	Sentrol / Securico / C-System / Briotronic / Rosslare
43	Local Scare Alarm	Sekurit / C-System / Briotronic / CPK Fire / Rosslare
44	Door Buzzer	Visionics / Vaishno / GE
45	Emergency Door Release	KAC / System Sensor / Sekurit / Sentrol / Rosslare
46	2 Core / 4 Core / Cable Access Control System Works	Lapp Cables / Belden Cables / Technoflex Cables / KEI International / Havells Cables
47	Panic Bar	Dorma / Yale / Godrej
48	Boom Barrier / Swing Barrier	Magnetic Auto Control / Skidata / Magtech / Gunnebo
49	X-Ray Baggage Scanner / Door Frame Metal Detector (DFMD)	Vehant / ECIL-Rapidscan / Smith Detection / Magtech
50	Under Vehicle Scanning System (UVSS)	Vehant / Magtech / Gatekeeper / WW Defsys
51	Perimeter Intrusion Detection System	Crown Solar / Gallagher / Green IP / TVS Sensing
E	IP CCTV SURVEILLANCE SYSTEM	
52	IP Cameras / Joystick / Video Management System Software / Video Management System Server / Recording Server with Built-in Storage / Analytic Server	Pelco / Hanwha Techwin / Tyco / Bosch / Honeywell / Vivotek
53	Surveillance Hard Disk Drive (HDD)	Seagate / Western Digital / Toshiba
54	Third Party CCTV AI Analytics Software	Ntech Lab / Ipsotek / Oosto / Intellivision Note: The required Server technical requirement as per the requirement Analytics Software OEM. The same shall be acknowledged by them on their letter head. The same shall be submitted while submitting the TDS for approval. Also the Analytics Software OEM shall get the acknowledgment from CCTV Camera OEM.
F	DATA NETWORKING & TELECOM SYSTEM	
55	CAT6A Cable and all Passive Networking Components	Commscope / Molex / Legrand / Panduit / R&M
56	Backbone Optical Fiber Cable & its Components	Commscope / Molex / Legrand / Panduit / R&M
57	All Ethernet Switches (Router / L3 Core Fiber Switch / L2 Edge Aggregation Switches and SFP Modules / Wi-Fi Access points / SDN Controller / Wi-Fi Controller / Enterprises Network Management System	Arista Networks / Extreme Networks / HP-Aruba / Allied Telesis
58	Firewall Equipment	Palo-Alto / Forti-Gate / Check Point / Sophos / Arista Networks
59	IP-ABX (VoIP / Analog Telephone)	Syntel / Matrix / Siemens / Zenitel / NEC
60	IP Phones & Soft Console IP Phones with Extension Keys	Syntel / Matrix / Siemens / Zenitel / NEC
61	Analog Telephone Handset	Beetel / Panasonic / Syntel / Matrix
G	MISCELLANEOUS ITEMS	
62	Modular Network Rack	Netrack / Legrand / R&M / Rittal

VOLUME III APPROVED MAKES LIST - ELV SYSTEM		
S. NO	ITEM	APPROVED MAKES / VENDORS
63	Operator Workstation and its Monitor	DELL / HP / IBM
64	CCTV Display Monitor Panel	Samsung / Sony / Sharp / Delta / LG
65	CCTV Display Controller	Dexon / VuWall / Datapath / Dhrita
66	Perforated Cable Tray / Floor Raceways / Wall Trunking Cover	Patny / Indiana / Profab / Pushbak / MEM
67	FRLS PVC Conduits	VIP / Precision / Astral / Anchor / Avan Plast
68	MS / GI Conduits	Bharat / Gupta / Supreme
69	HDPE Pipes - ELV & IBMS Services	Ashirvad / Utkarsh / Vectus / Apollo / Mangalam
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NOTE 2: In case during the execution of the Contract, makes mentioned in the list becomes unavailable, then it will be under obligation of the bidder to execute project as per the makes approved by "PMC/Employer"		
NOTE 3: The equipment will be supplied at site should not be manufactured from China and the same shall be rejected without any further reason. Successful Contractor shall replace all the materials without any further cost escalation, if found the materials will manufacture from China.		

VOLUME III APPROVED MAKES LIST – WATER SUPPLY (DOMESTIC AND RECYCLED) SYSTEMS		
Sr. No	Item	APPROVED MAKES / VENDORS
1	Sluice Valve	SANT/ Zoloto/ Leader/ Kirloskar/ Audco (L&T) / IVC / R & D Multiples / Durga valves
2	Butterfly Valve	Audco/ Advance/ Zoloto/ Sant/ Lehry/ Honeywell / Kirloskar / IVC / R & D Multiples / Durga valves
3	Motorized Butterfly Valves	Honeywell/ Belimo/ Siemens/ Johnson controls/ Kitz
4	Pressure Reducing Valves	Zoloto/ sant/ Watts/ UTAM/ Honeywell/ Lehry
5	Air Release Valve	Zoloto/ sant/ Watts/ Studor
6	uPVC & cPVC -water supply pipes and fittings	Astral/ Ashirwad/ Ajay
7	Actuators	Rexroth/ Avcon/ Honeywell/ Billimo/ Lehry
8	Water Meters / Electromagnetic Flow Meter	Deshmesh/ Aquamet Zenner/ Rockwin / Emerson / E&H / Siemens / Jumo / Forbes Marshall
9	HDPE Pipes	Reliance / Duraline / Jain / Supreme / George Fisher / Sangir / Supreme
10	DI Pipes	Electro Steel Castings / Jindal / Kejriwal / SriKalahasti pipes / Tata Metaliks
11	SFRC/ FRP Manhole Cover / Frames	Thermo Drains / Prolong Composite / Everlast / Fibrocast
NOTE 1: Contractor to proceed for procurement with preferred make, only upon approval from "PMC/Employer". Without written consent from "PMC/Employer", no procurement should be affected even if it is from the list of approved makes.		
NOTE 2: In case during the execution of the Contract, makes mentioned in the list becomes unavailable, then it will be under obligation of the bidder to execute project as per the makes approved by "PMC/Employer"		

VOLUME III APPROVED MAKES / VENDORS LIST – SEWERAGE WORKS		
S. NO	ITEM	APPROVED MAKES / VENDORS
1	DWC Pipes	Prince Piping Systems Gemini Pipes, Alom Poly Extrusions Ltd,
2	SFRC / FRP Manhole cover	Thermo Drains, Prolong Composite, Everlast, Fibrocast
NOTE 1: Contractor to proceed for procurement with preferred make, only upon approval from "PMC/Employer". Without written consent from "PMC/Employer", no procurement should be affected even if it is from the list of approved makes.		
NOTE 2: In case during the execution of the Contract, makes mentioned in the list becomes unavailable, then it will be under obligation of the bidder to execute project as per the makes approved by "PMC/Employer"		