

Shimla Jal Prabandhan Nigam Limited (SJPNL)

Design, supply, construction, installation, testing and commissioning of Sewage Treatment Plant of 1.40 MLD at Dhalli-II at Ghati Mohanpur Shimla based on Modern SBR technology including entire network with all contingent civil, (including staff quarter), electrical, mechanical, piping and instrumentation works with three months' trial run including three-year defect liability period, Shimla and operation & maintenance of entire system for 5 years.

BID DOCUMENT

For

Invitation for Bid No :

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VOLUME: II

(Technical Specifications/ Employer's Requirement)

Bidding on Design, Build & Operate Basis

Under National Competitive Bidding

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PART 4

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SECTION: I
TECHNICAL SPECIFICATIONS FOR CIVIL WORKS

SECTION: I TECHNICAL SPECIFICATIONS FOR CIVIL WORKS

1.1 Design Submissions

Complete detailed design calculations of foundations and superstructure together with general arrangement drawings and explanatory sketches shall be submitted by the Contractor to the Engineer. Separate design calculations for foundations or superstructures submitted independent of each other shall be deemed to be incomplete and will not be accepted by the Engineer.

Submissions of detailed design calculations and Good for Construction drawings shall include the following as a minimum:

A. Detailed Design Calculations

1. One (1) Copy of a Compact Disc (CD) containing electronic files relevant to the structure's modelling, analysis and design calculations (Microsoft Excel, Staad Pro, etc.). Files submitted shall be in editable format.
2. Print copy (6 Copies) of the contents as submitted in the Compact Disc.

B. Good for Construction Drawings

1. One (1) Copy of a Compact Disc (CD) containing AutoCAD files (Civil General Arrangement, Structural Dimensions and Reinforcement Details) pertaining to the structure. Files submitted shall be in editable format.
2. Print copy (6 Copies) of the contents as submitted in the Compact Disc. Prints to be submitted on A1 Size Sheet as a minimum or A0 Size Sheet when required by the employer.
3. Bar-bending schedule indicating the number, shape and size of the re-bars shall be submitted as part of the Reinforcement Details
4. Detailed drawing showing the location, number and depth of inserts shall be included for any structural steel inserts/Metal inserts in the structure such as rungs, bolted connections for ladders/railings, etc.
5. Location of Construction Joints and pour sequence shall be included on the drawing for base slabs, walls and top slabs.
6. Revised drawings shall be submitted by clouding at the location with the latest revision number and also show the history of revisions in a table format just above the title block.

The design considerations described hereunder establish the minimum basic requirements of plain and reinforced concrete structures, masonry structures and structural steel works. However, any particular structure shall be designed for the satisfactory performance of the

functions for which the same is being constructed. The Contractor shall also take care to check the stability of partly completed structures.

1.2 Design Standards

All the designs shall be based on the latest Bureau of Indian Standard (BIS) Specifications or Codes of Practice. The design standards adopted shall follow the best engineering practice. In case of any variation or contradiction between the provisions of the BIS Standards or Codes and the specifications given along with the tender document, the provision given in this Specification shall be followed.

All reinforced concrete structural design shall generally conform to the following publications of the Indian Standards Institution:

- (i) I.S. 456 : Code of Practice for plain and reinforced concrete
- (ii) I.S. 875 : Code of Practice for design loads for buildings and structures (Part I to V)
- (iii) I.S. 3370 : Code of Practice for concrete structures for the storage of liquids (Part I to IV)
- (iv) I.S. 1893 : Criteria for earthquake resistant design of structures (Part-1)
- (v) I.S. 2974 : Code of Practice for design and construction of machine foundations (Part 1 to 4)
- (vi) I.S. 4326 : Code of Practice for Earthquake Resistant Design and Construction of Buildings
- (vii) I.S. 13920 : Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces- Code of Practice
- (viii) IRC: 6 : Standard specification and Code of Practice for road bridges Loads and Stresses
- (ix) IRC: 21 : Standard specification and code of practice for road bridge, section III Cement Concrete
- (x) IRC 78 : Standard specification and code of practice for road and bridge, section VII Foundation & Sub-Structures

All structural steel design shall generally conform to the following publications of the Indian Standards Institution:

- (i) I.S. 800 : Code of Practice for general construction in steel
- (ii) I.S. 806 : Code of Practice for use of steel tubes in general building construction

1.3 Design Life

The design life of all structures and buildings shall be 60 years.

1.4 Design Loadings

All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these include dead load, live load, wind

load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, and dynamic loads:

1.4.1 Dead Load

This shall comprise all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipments and other items of machinery. In estimating the loads of process equipment all fixtures and attached piping shall be included, but excluding contents, shall be considered.

The following minimum loads shall be considered in design of structures:

(i)	Weight of water	:	9.81 kN/m ³
(ii)	Weight of soil (irrespective of strata available at site and type of soil used for filling etc). However, for checking stability against uplift, actual weight of soil as determined by field test shall be considered	:	20.00 kN/m ³
(iii)	Weight of concrete	:	24.00 kN/m ³
(iv)	Weight of reinforced concrete	:	25.00 kN/m ³
(v)	Weight of brickwork (exclusive of plaster)	:	22.00 N/m ² per mm thickness of brickwork
(vi)	Weight of plaster to masonry surface	:	18.00 N/m ² per mm thickness
(vii)	Weight of granolithic terrazzo finish or rendering screed, etc.	:	24.00 N/m ² per mm thickness
(viii)	Weight of MS chequered plates	:	78.5 N/m ² per mm thickness of plates

1.4.2 Live Load

Live Load (LL) shall include the superimposed loads due to the use/occupancy of the structure/building not including dead, wind or earthquake load. Live loads shall be in general as per I.S. 875 Part (II). However, the following minimum loads shall be considered in the design of structures:

(i)	Live load on roofs	:	1.50 kN/m ²
(ii)	Live load on floors supporting Equipment such as pumps, valves etc.	:	10.00 kN/m ²
(iii)	Live load on all other floors Walkways, stairways and Platforms	:	5.00 kN/m ²

In the absence of any suitable provisions for live loads in BIS Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Engineer prior to starting the design work. Apart from the specified live loads or any other

load due to material stored, any other equipment load or possible overloading during maintenance or erection/construction shall be considered and shall be partial or full whichever causes the most critical condition.

1.4.3 Wind Load

Wind loads shall be as per I.S. 875 Part (III).

1.4.4 Earthquake Load

This shall be computed as per I.S. 1893.

1.4.5 Dynamic Load

Dynamic loads due to working of plant items such as pumps, blowers, compressors, switch gears, travelling cranes, etc. shall be considered in the design of structures.

1.4.6 Wheel Load

For any structure or pipeline below the roads, Class A loading of IRC 6 shall be taken.

1.5 Joints

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure. However, contraction joints shall be provided at specified locations spaced not more than 7.5 m in both right angle directions for walls and rafts.

Expansion joints of suitable gap at suitable intervals not more than 30 m shall be provided in walls, floors and roof slabs of liquid retaining structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided on convenience of construction. To avoid segregation of concrete in walls, horizontal construction joints are normally to be provided at every 2 m height. PVC water-stops of 150 mm width shall be used for walls and 230 mm width for base slabs.

1.6 Design Conditions for Underground or Partly Underground Liquid Retaining Structures

All underground or partly underground liquid containing structures shall be designed for the following conditions:

- (i) Liquid depth up to full height of wall: no relief due to soil pressure from outside to be considered;
- (ii) Structure empty (i.e., empty of liquid, any material, etc.): full earth pressure, Outside water pressure if any and surcharge pressure wherever applicable , to be considered;

- (iii) Partition wall between dry sump and wet sump : to be designed for full liquid depth up to full height of wall;
- (iv) Partition wall between two compartments : to be designed as one compartment empty and other full;
- (v) Structures shall be designed for uplift in empty conditions with the water table as indicated in geotechnical report;
- (vi) Walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads;
- (vii) Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab. A minimum factor of 1.2 shall be ensured against uplift or floatation.
- (viii) All the liquid retaining structures shall be designed for maximum design crack widths of 0.1mm for direct tension and flexure.

1.7 Foundations

- (i) The minimum depth of foundations for all structures, equipments, buildings and frame foundations and load bearing walls shall be as per IS 1904 but in any case this shall not be less than 1.0 meter in the original soil.
- (ii) Safe bearing capacity of soil strata shall be taken as determined by the Contractor through his own independent investigations.
- (iii) Care shall be taken to avoid the foundations of adjacent buildings or structure foundations, either existing or not within the scope of this Contract. Suitable adjustments in depth, location and sizes may have to be made depending on site conditions. No extra claims for such adjustments shall be accepted by the Employer.
- (iv) Special attention is drawn to danger of uplift being caused by the ground water table. All underground structural slabs shall be designed for uplift forces due to ground water pressure.

1.8 Design Requirements

The following are the design requirements for all reinforced or plain concrete structures:

All blinding and levelling concrete shall be a minimum 150 mm thick in concrete grade M15.

- a) All liquid retaining reinforced concrete structures, concrete shall be of a minimum M30 grade with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all other structural member. All other

structures, reinforced concrete shall be of a minimum M25 grade with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all other structural member.

- b) The reinforced concrete for all structures shall have a minimum cement content of 375 kg/m³ with a maximum 20 mm size aggregate and 350 kg/m³ with a maximum 40 mm size aggregate. Reinforced concrete shall have maximum slump of 100mm with maximum water cement ratio of 0.48.
- c) As a design consideration to control crack, though general requirements of IS 3370 shall be followed, All liquid retaining structures shall be designed based on the serviceability crack width limit state (i.e. 0.1 mm crack width) and other limits including the ultimate limit states.
- d) The minimum cover to the main reinforcing bars for different members for non-liquid retaining structures shall be as follows unless stated otherwise:

Slab (Floor, Roof, Canopy, and Staircase)	30 mm
Beams (Sides, Bottom & Top)	40 mm
Columns	50 mm
Pedestals (in contact with earth)	50 mm
Basement wall, retaining walls	
i) Face in contact with earth	40 mm
ii) Interior face	30 mm
iii) Foundations	50 mm

NOTE: The minimum clear cover to all reinforcement including stirrups and links shall be 50 mm for all liquid retaining structures.

- e) In general, reinforcement for buildings and sewage treatment units shall be HYSD-CRS (Corrosion Resistant Steel) of Grade Fe 500. All physical and chemical properties of this Fe 500 grade steel shall conform to IS: 1786-2008. Welded wire fabric shall conform to IS: 1566 as shown or specified on the drawing. The CRS (corrosion resistant steel) index shall be at least 1.35 when tested for Salt Spray test as per "ASTM B 117 – 2009 test procedure for 120 hours when compared with the Fe 500 normal reinforcement bars and with same bar diameter. All test results (including physical and chemical properties and salt spray tests) have to be produced for the respective bar diameter for each consignment of steel delivered at site and at a frequency of every 20 Metric Tons.
- f) Reinforcement produced using iron ore as the raw material only will be accepted. Reinforcement produced from scrap metal will not be accepted.
- g) The amount of reinforcement in each of the two directions at right angles within each surface zone should not be less than 0.35% of the surface zone cross section (As per cl.

2.6.2.3 of BS: 8007-1987). For slabs, minimum of 10 mm dia bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction.

- h) All buildings shall have a minimum 1 meter wide, 100 mm thick plinth protection paving in M15 grade concrete or stone slabs/tiles. All plinth protection shall be supported on well compacted strata.
- i) All pipes and ducts laid below the structural plinth and road works shall be surrounded with concrete of grade M15 having minimum 150 mm thick concrete or D/4 (D = outer dia. of pipe) thickness whichever is more.
- j) Use of pressure relief valves to reduce uplift pressure due to ground water table shall not be allowed.
- k) Detailing of the reinforcement shall be done as per latest IS-13920 considering Earthquake Seismic Zone-IV.
- l) Sliding layer or slip layer shall be provided between sub base and structural slab (Raft). Polythene sheets of 500 gauge shall be provided as sliding layer as per IS specification.
- m) Water tightness testing of water retaining structures shall be done in accordance with IS: 3370, Part I. It is described in **Clause 1.22**. The depth of water for testing shall be up to the soffit of the covering slab.

The following minimum thicknesses shall be used for different reinforced concrete members, irrespective of design thicknesses:

(i)	Walls for liquid retaining structures	:	250 mm
(ii)	Roof slabs for liquid retaining structures	:	200 mm
	(Other than flat slabs)		
(iii)	Bottom slabs for liquid retaining structures	:	250 mm
(iv)	Floor slabs including roof slabs, walkways,		
	Canopy slabs	:	125 mm
(v)	Walls of cables / pipe trenches,		
	Underground pits etc.	:	200 mm
(vi)	Column footings	:	300 mm
(vii)	Parapets, chajja	:	100 mm
(viii)	Precast trench cover	:	75 mm
(ix)	Column Dimensions	:	300 mm

1.9 Materials in General

The term "materials" shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.

Except as may be otherwise specified for particular parts of the works the provision of clauses in "Materials and Workmanship" shall apply to materials and workmanship for any part of the works.

All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

As soon as practicable after receiving the order to commence the Works, the Contractor shall inform the Engineer of the names of the suppliers from whom he proposes to obtain any materials but he shall not place any order without the approval of the Engineer which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Engineer informed of orders for and delivery dates of all materials. Materials shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination failing which such damaged materials will be rejected and shall not be used on any part of the Works under this contract.

1.10 Samples and Tests of Materials

The Contractor shall submit samples of such materials as may be required by the Engineer and shall carry out the specified tests directed by the Engineer at the Site, at the supplier's premises or at a laboratory approved by the Engineer.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer.

The Contractor shall give the Engineer seven days' notice in writing of the date on which any of the materials will be ready for testing or inspection at the supplier's premises or at a laboratory approved by the Engineer. The Engineer shall attend the test at the appointed place within seven days of the said date on which the materials are expected to be ready for testing or inspection according to the Contractor, failing which the test may proceed in his absence unless instructed by the Engineer to carry out such a test on a mutually agreed date in his presence. The Contractor shall in any case submit to Engineer within seven days of every test such number of certified copies (not exceeding six) of the test results as the Engineer may require.

Approval by the Engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer's powers under the Contract.

The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

1.11 Standards

Materials and workmanship shall comply with the relevant Indian Standards (with amendments) current on the date of submission of the tender.

Where the relevant standard provides for the furnishing of a certificate to the Engineer, at his request, stating that the materials supplied comply in all respects with the standard, the Contractor shall obtain the certificate and forward it to the Engineer.

The specifications, standards and codes listed below are considered to be part of this specification. All standards, specifications, codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

In case of discrepancy between the Specification and the Standards referred to herein, the Specification shall govern.

a) Materials

- IS: 269 - Specification for 33 grade ordinary Portland cement
- IS: 383 - Specification for coarse and fine aggregates from natural sources for concrete
- IS: 428 - Specification for distemper, oil emulsion, colour as required
- IS: 432 - Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (Parts 1 & 2)
- IS: 455 - Specification for Portland slag cement
- IS: 458 - Specification for precast concrete pipes (with and without reinforcement)
- IS: 650 - Specification for standard sand for testing of cement
- IS: 651 - Specification for salt glazed stoneware pipes and fittings
- IS: 808 - Specification for dimensions for hot rolled steel beam, column channel and angle sections
- IS: 814 - Specification for covered electrodes for manual metal arc welding of Carbon and Carbon Manganese steel
- IS: 1003 - Specification for timber panelled and glazed shutters (Parts 1 & 2)
- IS: 1038 - Specification for steel doors, windows and ventilators
- IS: 1077 - Specification for common burnt clay building bricks
- IS: 1398 - Specification for packing paper, water proof, bitumen laminated
- IS: 1489 - Specification for Portland pozzolana cement (Parts 1 & 2)
- IS: 1566 - Specification for hard drawn steel wire fabric for concrete reinforcement
- IS: 1580 - Specification for bituminous compounds for water proofing and caulking purposes
- IS: 1786 - Specification for high strength deformed steel bars and wires for concrete reinforcement
- IS: 1852 - Specification for rolling and cutting tolerances for hot rolled steel products
- IS: 1948 - Specification for aluminium doors, windows and ventilators
- IS: 1977 - Specification for structural steel (ordinary quality)
- IS: 2062 - Specification for steel for general structural purposes
- IS: 2185 - Specification for concrete masonry units (Parts 1 & 2)
- IS: 2202 - Specification for wooden flush door shutters (Parts 1 & 2)
- IS: 2645 - Specification for integral cement water proofing compounds
- IS: 2750 - Specification for steel scaffoldings

- IS: 2835 - Specification for flat transparent sheet glass
- IS: 3384 - Specification for bitumen primer for use in waterproofing and damp proofing
- IS: 3502 - Specification for steel chequered plates
- IS: 4021 - Specification for timber door, window and ventilator frames
- IS: 4350 - Specification for concrete porous pipes for under drainage
- IS: 4351 - Specification for steel door frames
- IS: 4990 - Specification for plywood for concrete shuttering work
- IS: 8112 - Specification for 43 grade ordinary Portland cement
- IS: 9862 - Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and chlorine resisting
- IS: 10262 - Recommended guidelines for concrete mix design
- IS: 12269 - Specification for 53 grade ordinary Portland cement
- IS: 12330 - Specification for sulphate resisting Portland cement
- IS: 12709 - Glass fibre reinforced plastics (GRP) pipes, joints and fittings for use for potable water supply

b) Tests

- IS: 516 - Method of test for strength of concrete
- IS: 1182 - Recommended practice for radiographic examination of fusion - welded butt joints in steel plates
- IS: 1199 - Methods of sampling and analysis of concrete
- IS: 2386 - Methods of test for aggregates for concrete (Parts 1 to 8)
- IS: 2720 - Methods of test for soils (Parts 1 to 39)
- IS: 3025 - Methods for sampling and test (physical and chemical) for water and wastewater (Parts 1 to 59)
- IS: 3495 - Method of test for burnt clay building bricks (Parts 1 to 4)
- IS: 3613 - Acceptance tests for wire flux combination for submerged arc welding
- IS: 4020 - Methods of tests for wooden flush doors shutters: Type tests
- IS: 4031 - Methods of physical tests for hydraulic cement (Parts 1 to 15)
- IS: 5807 - Method of test for clear finishes for wooden furniture (Parts 1 to 6)
- IS: 7318 - Approval tests for welders when welding procedure approval is not required (Parts 1 and 2)
- IS: 13311 - Methods of Non-destructive testing of Concrete- Part 1 & Part 2

c) Codes of Practice

- IS: 456 - Code of practice for plain and reinforced concrete
- IS: 783 - Code of practice for laying of concrete pipes
- IS: 800 - Code of practice for general construction in steel
- IS: 806 - Code of practice for use of steel tubes in general building construction
- IS: 816 - Code of practice for use of metal arc welding for general construction in mild steel
- IS: 817 - Code of practice for training and testing of metal arc welders

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- IS: 875 - Code of practice for design loads (other than earthquake) for building structures (Parts 1 to 5)
- IS: 1081 - Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators
- IS: 1172 - Code of practice for basic requirements for water supply, drainage and sanitation
- IS: 1477 - Code of practice for painting of ferrous metals in buildings (Parts 1 & 2)
- IS: 1597 - Code of practice for construction of stone masonry (Parts 1 & 2)
- IS: 1742 - Code of practice for building drainage
- IS: 1893 - Criteria for earthquake resistant design of structures
- IS: 1904 - Code of Practice for Design and Construction of Foundation in Soils: General Requirements.
- IS: 2065 - Code of practice for water supply in buildings
- IS: 2212 - Code of practice for brickwork
- IS: 2338 - Code of practice for finishing of wood and wood based materials (Parts 1 & 2)
- IS: 2394 - Code of practice for application of lime plaster finish
- IS: 2395 - Code of practice for painting, concrete, masonry and plaster surfaces (Parts 1 & 2)
- IS: 2470 - Code of practice for installation of septic tanks (Parts 1 & 2)
- IS: 2502 - Code of practice for bending and fixing of bars for concrete reinforcement
- IS: 2571 - Code of practice for laying in-situ cement concrete flooring
- IS: 2595 - Code of practice for radiographic testing
- IS: 2751 - Recommended practice for welding of mild steel plain and deformed bars for reinforced construction
- IS: 2974 - Code of practice for design and construction of machine foundations (Parts 1 to 4)
- IS: 3114 - Code of practice for laying of Cast Iron pipes
- IS: 3370 - Code of practice for concrete structures for the storage of liquids (Parts 1 to 4)
- IS: 3414 - Code of practice for design and installation of joints in buildings
- IS: 3558 - Code of practice for use of immersion vibrators for consolidating concrete
- IS: 3658 - Code of practice for liquid penetrant flaw detection
- IS: 3935 - Code of practice for composite construction
- IS: 4000 - Code of practice for High strength bolts in steel structures
- IS: 4014 - Code of practice for steel tubular scaffolding (Parts 1 & 2)
- IS: 4111 - Code of practice for ancillary structures in sewerage system (Parts 1 to 4)
- IS: 4127 - Code of practice for laying of glazed stoneware pipes
- IS: 4326 - Code of practice for Earthquake Resistant Design and Construction of Buildings
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- IS: 4353 - Recommendations for submerged arc welding of mild steel and low alloy steels
- IS: 5329 - Code of practice for sanitary pipe work above ground for buildings
- IS: 5334 - Code of practice for magnetic particle flaw detection of welds
- IS: 5822 - Code of practice for laying of welded steel pipes for water supply
- IS: 7215 - Tolerances for fabrication of steel structures
- IS: 9595 - Recommendations for metal arc welding of carbon and carbon manganese steels
- IS: 10005 - SI units and recommendations for the use of their multiples and of certain other units

d) Construction Safety

- IS: 3696 - Safety code for scaffolds and ladder (Parts 1 & 2)
- IS: 3764 - Safety code for Excavation work
- IS: 7205 - Safety code for erection of structural steel work

1.12 General Arrangement of Plant

The following general guidelines shall be followed in the preparation of general arrangement of Plant:

- Sufficient room shall be allowed between items of plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance;
- An area adjacent to all mechanical Plant shall be provided as maintenance lay down area;
- fixed runways, lifting eyes or other means shall be provided to permit the removal of Plant that may be required to be removed during the course of its normal operational life for maintenance or any other purpose;
- areas where leakage is likely to occur whether in normal use or during maintenance shall be provided with covered drainage channels which shall direct spillage either to a suitable plant drain or to a sump from where it can be pumped to plant drain;

1.13 Orientation

The works shall be laid out within the confines of the Site in order to interface to the existing infrastructure of roadways and inlet and outlet pipe work. Underground services requiring to be relocated in order to accommodate the proposed site layout shall, with the approval of the Engineer, be relocated by the Contractor.

1.14 Buildings and Structures

All the building and structure works shall generally comply with the following Employer's Requirements unless otherwise specified elsewhere:

All building works shall be of reinforced concrete framework.

All internal and external walls shall be in solid cement concrete blocks of concrete grade M15 and shall be provided as per IS: 2185 (Latest Revision) and shall be 200 mm thick or 230 mm thick brick masonry walls.

Toilet partition walls shall be in 100 mm thick solid concrete block or 115 mm thick brick masonry walls.

4. (a) Finishes to concrete liquid retaining structures shall be :

- F1 - External surfaces, buried
- F2 - External surfaces exposed and up to 300 mm below ground level
- F2 - Internal surfaces

(b) Finishes to other concrete structures shall be :

- F1 - Buried
- F1 - Exposed, where plastering is specified
- F2 - Exposed

5. All internal masonry surfaces finish shall have 12 mm thick plain faced cement plaster in cement mortar (1:4) with neat cement finish on top. Over this, one coat of primer and two coats of plastic emulsion paint of approved quality and shade shall be provided.
6. All external masonry and concrete with rough board finish shall have 20 mm thick sand faced cement plaster in two coats, base coat 12 mm thick in cement mortar 1:4 and finishing coat 8 mm thick in cement mortar 1:4. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.
7. All external surfaces above ground level shall have one coat of primer and two coats of waterproof cement based paint of approved quality and shade. A coat of silicone water repellent paint shall also be applied thereon.
8. Toilet areas, walls and ceilings, shall have one coat of primer and two coats of plastic emulsion paint.
9. Toilet floor slab shall be filled with brick bat coba (broken bricks in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company.
10. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.
11. The flooring in all areas except toilets, staircases, pumping stations, chlorination building, centrifuge building, workshop, D.G.Room shall be in 250 mm x 250 mm x 20 mm thick marble mosaic tiles of approved make unless otherwise specified, shade and pattern and placed in cement mortar 1:4 to give overall thickness of 50 mm. Half tile skirting shall also be provided in these areas.

12. The flooring in the pumping stations, chlorination building, sludge dewatering building, maintenance workshop, D.G. Room shall be 60mm thick cement flooring with Metallic concrete hardener topping, under layer of 42mm thick cement concrete 1:2:4 (1 cement : 2 coarse : 4 graded stone aggregate 16mm thick nominal size) and top layer of 18mm thick metallic concrete hardener consisting of mix 1:2 (1 cement : 2 stone aggregate 6mm nominal size) by volume & mixed with metallic hardening compound of approved quality @ 3 kg/m². Including cement slurry and rounding off edges.
13. Chlorine and chemical buildings should be acid resistant.
14. The flooring in operator's room, loading/unloading bay, MCC cum Panel room shall be in 25mm thick Kota stone slab of approved shade and pattern and placed over 20 mm thick base of cement mortar 1:4 to give overall thickness of 45 mm. Half tile skirting shall also be provided in these areas.
15. Toilet areas shall have 450 mm x 450 mm x 25 mm thick polished Kota stone tiles placed in cement mortar 1:4 to give an overall thickness of 50 mm. 2100 mm high dado, in 150 mm x 150 mm x 6 mm thick glazed tiles (approved make, shade and pattern) placed in cement mortar 1:3 shall also be provided in these areas.
16. The flooring along with skirting in administration cum laboratory building shall be 20 mm thick mirror polished, machine cut granite slab of approved shade and pattern placed in cement mortar (1:4). 150mm high skirting shall be provided in these areas. Granite stone shall be provided for laboratory platforms fixed over double sandwiched cuddappah support as directed and the edges of granite is to be embedded into the wall.
17. **The toilet facilities shall include at least :**
 - (i) 2 Nos. Water closets with white porcelain Orissa pan minimum 580 mm long with low level flushing cistern of 10 litres capacity.
 - (ii) 2 Nos. Urinals of sizes 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a marble partition of size 680 mm x 300 mm.
 - (iii) 2 Nos. wash basins of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.
 - (iv) 2 Nos. mirror of size 400 mm x 600 mm wall mounted type fitted over wash basins.
 - (v) 2 Nos. plastic liquid soap bottles
 - (vi) 2 Nos. chromium plated brass towel rails minimum 750 mm long.
 - (vii) All stopcocks, valves and pillar cocks shall be heavy duty chromium plated brass.

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- (viii) All fittings such as 'P' or 'S' traps, floor traps, pipes, down take pipes etc.
- (ix) The sewage from toilet blocks shall be led to the wet well of terminal sewage pumping station if present or included under this contract or to the closest gravity sewer.
18. All staircases shall have 25 mm thick chequered mosaic tiles for treads and 25 mm thick plain mosaic tiles for risers of approved make and shade and half tile skirting set in cement mortar in 1:4 to give an overall thickness of 50 mm.
- All concrete stairs shall have aluminium nosing over 2 mm thick rubber strip of width same as nosing for the full length of the tread. Nosing shall be fixed with countersunk screws.
19. Stairways shall be provided to permit access between different levels within buildings. Staircase shall be minimum 1000mm wide unless specified otherwise. Staircases in general shall not be steeper than 40°. Staircases having space constraints may be steeper than 40°. The maximum vertical run for a single flight of stairs shall be 3.0 M.
20. All roof tops and overhead tanks shall be made accessible with ladder provision. Vertical step ladders fitted with landing point extensions will be permitted where considered appropriate by the Engineer to access areas not frequently visited.
- Steel staircases shall be constructed of standard channel stringers with M.S. grating treads 25mm thick with non skid nosing. Steel Ladders shall be minimum 600mm wide and shall not exceed 6m of straight run. The ladders shall be painted with epoxy paint.
21. All hand railing (3-rail) shall be provided with 6063-T6 Aluminium Alloy with an ultimate tensile strength of at least 207 MPa and yield strength of at least 172 MPa. The minimum height of hand railing shall be 1m and maximum spacing of verticals shall be 1.5 m.
22. The reinforced concrete roofs shall be made waterproof by application of an approved roof polythene / bitumen membrane / brick bat coba. The finished roof surface shall have adequate slope to drain quickly the rain water to R.W down take inlet points.
23. All roof floors shall have minimum 750 mm height solid concrete block parapet wall where accessible is provided and shall have minimum 300 mm height solid concrete block parapet wall where accessible is not provided.
24. For roofing drainage, cast iron or uPVC rainwater down takes with C.I. bell mouth or uPVC bend and C.I. or uPVC grating at top shall be provided. For roof areas up to 40 sq m minimum two nos. 100 mm diameter down take pipes shall be provided. For every additional area of 40 sq m or part thereof, at least one no. 100 mm dia. down take pipe shall be provided.
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25. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rain water.
26. Building plinth shall be minimum 450 mm above average finished ground level around building or high flood level whichever is more.
27. All doors, windows, rolling shutters shall have lintels above. Chajja protection to lintels on external walls shall be such as to prevent the rain water splashing into the building. Chajja projection of minimum 750 mm for rolling shutters, 600 mm for doors and 450 mm for windows shall be provided to prevent the rain water splashing into the building. Chajja shall be projected 150 mm on either sides from size of doors/windows/rolling shutters.
28. All windows and ventilators shall have 25 mm thick Kota stone sills bedded in cement mortar (1:3).
29. All doors and windows shall be painted with two coats of synthetic enamel paint over a priming coat (ready mixed Zinc Chromate Yellow primer of approved brand and manufacturer confirming to I.S.: 127-106, 341 and 340).
30. All doors, windows and ventilators shall be made of aluminium confirming to latest version of IS: 1948. All fixtures for doors, windows and ventilators shall also be of aluminium. Aluminium grills shall be provided in all the windows. Doors shall be in two panel and both panels shall be glazed/unglazed. Minimum weight of aluminium doors & windows shall be as follows

I. Single Glazed Window : (Weights indicated shall be aluminium)

a) Openable

Outer Frame	:	Weight 0.70 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.97 kg/Rmt
Beading	:	Weight 0.31 kg/Rmt
Fixing Louvers windows/ventilators		

Outer Frame	:	Weight 0.46 kg/Rmt
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II. Double Glazed Window

Outer Frame	:	Weight 0.72 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.98 kg/Rmt
Beading	:	Weight 0.31 kg/Rmt

III. Sliding Windows

Bottom & Top Frame :	Weight 0.70 kg/m
Shutter Frame :	Weight 0.42 kg/m
Interlocking Section :	Weight 0.47 kg/m

IV. Aluminium Door

Outer Frame :	Weight 2.508 kg/Rmt
Shutter Frame :	Weight 2.508 kg/Rmt
Bottom Stile :	Weight 2.508 kg/Rmt

Glazing shall be 5.5 mm thick glass.

31. Openings of the windows & ventilators shall be minimum 25% of the external wall area.
32. Ventilator shall be provided where height of floor is more than 3m.
33. All windows and ventilators shall have wire mesh. Frame of doors, windows and ventilators shall be of aluminium of standard rolled section. Doors, Windows and Ventilators shall be of size as per schedule to be submitted by the Contractor for approval of Engineer. The minimum size shall be as per below:
- Door of opening size 1.2m x 2.1m
- Door of opening size 0.75m x 2.1m for toilets
- Glazed windows of minimum size 1.2m x 1.2m
- Ventilators of minimum size 0.6m x 0.6m
34. Rolling shutters shall be made of 80 x 1.25 mm MS laths. Rolling shutter shall be of minimum size 3m wide x 3.0m high. Rolling shutter shall be provided in MCC cum panel room, chlorine tonner shed, at entry and exit of the pump house for access to pumps, motors, valves, panels and as wherever required.
35. All concrete channels and ducts used for conveying liquid shall have inside finish of type F2. The width of concrete channels shall not be less than 500 mm. All open channels shall be provided with Aluminium hand railings (3-rail) or concrete walls to a minimum height of 1 m from the access surface elevation. All concrete surfaces of structures conveying raw sewage or primary effluent upstream of the aeration tanks shall be protected from corrosion with an approved internal epoxy lining.
36. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of Factory Act. It shall not be less than 150mm.
37. All exposed surfaces of inserts embedded in concrete shall be painted with two coats of enamel paint over one coat of red oxide zinc chrome primer. Surfaces in contact with concrete shall not be painted.
38. All structural steel members shall be painted with two coats of enamel paint over one shop and one field coat of red oxide zinc chrome primer.

39. All rooms in the treatment plant buildings shall be provided with appropriate sign boards indicating the function of the rooms involved written in Gujarati and English Languages.
40. The design of buildings shall reflect the climatic conditions existing on site. Process buildings shall as far as possible permit the entry of natural light, and the use of glazed panelling shall be kept to a minimum and preference given to wall openings protected by weather canopies.
41. Emergency exit doorways shall be provided from all buildings in order to comply with local fire safety regulations. Stairways and paved areas shall be provided at the exit points.
42. Toilet blocks in process buildings and control blocks shall be provided with a sink with two drinking water taps of 20 mm size with adequate inlet and outlet connections.
43. All the walkways shall have minimum 1 m width and shall be covered with mosaic tiles. Walkways to be provided with 6063-T6 Aluminium Alloy hand railings.
44. Anaerobic Sludge Digesters and Sludge Tank shall be built in RCC. A top dome of digesters shall be made of M.S. Steel work with inside surface of the dome shall be coated with Epoxy Coating as approved by Engineer and top surface Ring Beam and top 2m wall of the digester shall also be coated with Epoxy Coating. Contractor may submit his proposal for the alternative materials which can be used for digester dome along with all technical details. Employer will approve the type of material which shall be used for the construction digester domes depending upon the durability, corrosion resistivity, strength, ease in operation, functional requirements, economy, etc.
45. All concrete structures in contact with sewage and/or sludge upstream of the Aeration Basins shall be provided with full interior corrosion protection linings and/or coatings of appropriate material and thickness – to be approved by Employer. This also applies to all concrete structures in contact with any type of sewage sludge anywhere in the plant. For Aeration Basins, interior lining shall extend from the top of wall down to 1.0 meter below the lowest operating water level.
46. For structures containing water or process liquid, the top of the wall shall be at least 0.5m higher than the maximum water surface level calculated at peak plant flow.
47. The top level of internal plant roads and approaches shall be at least 0.5m above the site High Flood Level. If the High flood level is more than Ground Level then road shall be constructed on the earthen embankment. Earthen embankment shall be constructed with side slope of at least 2 horizontal to 1 vertical. Stone pitching shall be provided at both sides of the embankment as per IS: 8237. Top width of embankment shall be taken as 6.0m. Top level of embankment shall be 0.5m above high flood level. Excavated earth from the plant can be used for embankment

construction and if required, extra earth can be borrowed from the borrow pit as approved by Engineer.

48. All water retaining structures for sewage application shall be constructed in Sulphate Resistant Cement (SRC) and for raw/treated water application & buildings shall be constructed in OPC Grade 53 as per IS specifications.

1.15 Roadways, Pathways & Hard standings

A comprehensive network of roadways shall be provided around the treatment plant to link in with the existing road network and permit access to the plant for necessary maintenance, delivery of consumables and personnel access. All roads shall be of asphalt macadam/concrete and internal roads minimum 4.50 metres wide. Approach road and main road shall be minimum 6.0m wide. Vehicular access shall be provided for all Plant structures and buildings. All roads shall be provided with drainage and shall be constructed to prevent standing water.

Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking plant areas. Damage to any existing roads on account of their use by the Contractor shall be made good to the satisfaction of the Engineer.

Hard standing areas with shading facility shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the works and out again.

1.16 Site Drainage

The Contractor shall provide a site drainage system. The system shall comprise of the following:

- Storm Water Drainage
- Foul Drainage

1.16.1 Storm Water Drainage

Storm water drains adjacent to the existing and proposed roads (under this Contract) shall be sized for a rainfall intensity of 50 mm/hr, allowing for 100% runoff. Drains adjacent to roads shall be in stone masonry in CM (1:4) of appropriate thickness, topped with 75 mm thick M10 concrete and internally flush pointed in cement mortar (1:4), 20 mm thick. The minimum width of drain shall be 450mm.

The storm water drainage system shall also be designed to cater the run-off from the existing plot areas and structures, if necessary depending upon the site topography.

1.16.2 Foul Drainage

The foul drainage system shall accept discharge from toilets, washrooms, offices and the laboratory. The foul drainage system shall be conveyed to either wet-well of the terminal sewage pumping station wherever exist or proposed under this contract or nearest public sewer wherever exist.

1.17 Cable and Pipe work Trenches

Cable and pipe-work trenches shall generally be constructed in reinforced concrete. However, 500 mm x 500 mm size or smaller trenches, not on fill may be constructed in 200 mm thick solid cement concrete blocks over 150mm thick M 15 PCC base. The trenches will be 20mm thick plastered internally with cement mortar (1:4) and externally in cement mortar (1:3).

All floor cut-outs and cable ducts, etc. shall be covered with M20 precast concrete covers (Heavy Duty) or MS grating as per direction of Engineer in outdoor areas and M.S. chequered plates, suitably painted of adequate thickness in indoor areas. All uncovered openings shall be protected with hand railing. The pipe, cable trenches shall be suitably sloped to drain off rainwater to a suitable location.

Layout of trenches outside the buildings shall allow space for construction of future trenches where necessary with due consideration for planning for future developments. This aspect shall be brought to the notice of the Engineer while planning the works.

1.18 Pipes and Ducts

R.C.C ducts for drainage shall have minimum 1 metre pre-cast cover (M20 concrete, Heavy duty) while laid under roads. Access shafts of size not less than 600 mm x 1000 mm shall be provided.

All drains (except storm water drains adjacent to roads) shall be covered and designed structurally for appropriate loads.

1.19 Main Gate

Each proposed treatment plant shall have one main gate to access the plant irrespective of existing gate at the premises of existing plant site. Minimum width of main gate shall be 6m. Main gate shall have 1.5m wide wicket gate. Main gate shall have as external framework of GI pipes and internal framework of MS flats. Gate shall be fixed on RCC columns. The design and pattern of gate with drawing shall be submitted for approval of the Engineer. The gate shall have all necessary hinges, locking arrangement, rolling arrangement and painting complete, as approved by the Engineer.

1.20 Landscaping

The site shall be landscaped once the Works are substantially complete. Landscaping area shall be marked in the layout plan of STP site. The area of landscaping shall not be less than 33% of the proposed plant layout area.

Landscaping shall include planting of suitable trees and development of lawn/grassed areas. Landscaping in general shall meet ecological and environmental conditions of the site. Road widths shall determine the size of the tree height and spread to be selected for planting. Trees suitable for local conditions shall be selected as approved by the Engineer. Medicinal and fruit trees shall be avoided. Landscaping shall be maintained in good condition till the completion of the contract.

Tree Planting

Pits dug a few days in advance of actual planting shall be allowed to weather and be filled with top soil mixed with manure. Size of the pit shall be as per standard requirement. Only one tree shall be planted in each pit. A guard made of bamboo with wire mesh or bricks or M.S. ring as approved by Engineer, shall be provided.

1.21 Applications for Anti-Corrosive Internal Lining (Epoxy Coating) protection of Concrete Surfaces

Application limits of Anti-Corrosion Internal Lining for Concrete Surfaces:

1. All units upstream of and including Primary Clarifiers will have to be provided with internal lining for the full internal surface area (Walls and base slab)
2. For the Aeration units - internal lining shall be provided on the walls only from the top of the structure to 1.0 m below the lowest operating liquid level
3. For the units handling the solids part such as: Gravity Sludge Thickener, Anaerobic Sludge digester and Digested Sludge Storage tank, internal lining shall be provided for the entire internal surface area.

Hydraulic Testing of Liquid Retaining Structures

In addition to the structural test of structures, the liquid retaining structures shall also be tested for water tightness test at full supply level as described in 10.1.1, 10.1.2 and 10.1.3 of latest revision of IS 3370 (Part I).

On completion of the structure and before its commissioning, the Contractor shall carry out a water tightness test for the maximum water head condition i.e. with the water standing at Full Supply Level (FSL). This test shall be carried out preferably in dry season and prior to internal lining in accordance with the procedure given below:

The water tightness test shall be carried out when the construction of liquid retaining structure is done and when it is possible to fill the structure and ensure that uniform settlement of the structure as a whole or as directed by the Engineer. Before the filling operations are started the structure shall be inspected by the Engineer and the Contractor's Representative and the condition of surfaces of walls, contraction joints shall be noted and it shall be ensured that the jointing material filled in the joint is in position and all openings are closed. The Contractor shall make necessary arrangement for ventilation and lighting of the structure by way of floodlights, circulators etc. for carrying out proper inspection of the

surfaces and inner conditions if so desired by the Engineer. Records of leakages starting at different levels of water in the reservoir, if any, shall be kept.

The liquid retaining structure once filled shall be allowed to remain so for a period of seven days before any readings of drop in water level are recorded. The level of the water shall be recorded against the subsequent intervals of 24 hours over a period of seven days. The total drop in surface level over a period of seven days shall be taken as an indication of the water tightness of the structure, which for all practical purposes shall not exceed 40 mm. Also there shall be no indications of the leakages around the opening or on the walls.

If the structure does not satisfy the condition of test and the daily drop in water level is decreasing, the period of test may be extended for a further period of seven days and if the specified limit is then reached the structure may be considered as satisfactory.

The external faces of structure shall not show any signs of leakage and shall remain apparently dry over the period of observation of seven days after allowing a seven day period for absorption after filling.

In case the drop in level exceeds the permissible level limit and signs of leakage with the stipulated period of test, the Contractor shall carry out such additional works and adopt such measures as may be directed by the Engineer to reduce the leakage within the permissible limits. The entire rectification work that shall be carried out in this connection shall be at the Contractor's cost. The water required for subsequent testing shall be supplied to the Contractor free of cost, if the same is available near the site. Contractor shall have to make arrangement for filling emptying the structure at his own cost.

If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water retaining structures test procedures, at his own cost. Should the re-test results still be unsatisfactory after the repairs, the structure will be condemned and the Contractor will dismantle and reconstruct the structure, to the original specification, at his own cost.

During testing and during defect liability period the impression marks created due to seepage shall be rectified and made good.

No separate payment shall be made for water tightness test and the cost thereof shall be deemed to be covered in the price quoted of different items of work of Sewage Treatment Plant.

1.23 Compound Wall

The compound wall (TYPE A or TYPE B) shall be constructed along the boundary of STP site (considering plant layout for intermediate and ultimate build out capacity and 33% landscaping area).

TYPE A

Compound wall shall be of stone masonry of approved quality and type. The wall shall be min. 300mm thick and the height shall be 2 meter above natural ground level. Minimum foundation depth shall be 0.75m below ground level. Necessary expansion joints shall be provided as per approved drawings.

Pilasters at 5 meters spacing shall be provided along the length of the compound wall. Also coping, broken glass set, fabricated MS angles, GI barbed wire fencing 0.75 meter high on wall top shall be provided, all as approved by the Employer's Representative. Cement Mortar Pointing (CM 1:4) shall be provided on both side of the wall.

TYPE B

Compound wall shall consist of RC precast slab panels (M25), RC post at regular intervals including plinth beam as supports for the panels and necessary RC foundation system for the same along with barbed wire stretched between MS angles fixing at the top of the precast panels with necessary fixtures etc., (Typical Drawing enclosed).

All structural designs and Specifications shall confirm to relevant Codal provisions.

SECTION: II
TECHNICAL SPECIFICATIONS FOR MECHANICAL WORKS

SECTION: II TECHNICAL SPECIFICATIONS FOR MECHANICAL WORKS

1.1 INTRODUCTION

This part of Owner's requirements sets out the general standards for mechanical equipment to be used by the contractor for the works. Any item not mentioned herein but required for completion of work shall have to be taken into account by the contractor. Reference to any specific items does not necessarily imply that it is to be included in the works. All equipment used for the works shall, unless otherwise specified, comply with the provisions of this chapter.

Successful Bidder has to submit the list and schedule of all design / drawings / calculation / QAP/ etc., within 1 month of issue of LOI.

1.2 GENERAL

1.2.1 Material

All materials incorporated in the works shall be the most suitable for the duty concerned and shall be new & from reputed/approved make or approved quality and of first class commercial quality, free from imperfection and selected for long life and minimum maintenance. Destructive/Non-destructive tests, if called for, shall be carried out. All the moving parts of the plant, or shaft and spindles or faces etc. In contact with then shall be of corrosion resistance materials. All parts directly in contacts with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall maintain their properties without aging due to the passages of time, exposure to light or any other causes. All material shall confirm to the material as per BIS or any equivalent standard. All stainless steel materials used shall be of SS 316 unless otherwise specified.

1.2.2 Workmanship

Workmanship and general finish shall be of first class quality and in accordance with best workshop practice. All welds shall be as per BIS or any equivalent standards. All tolerances and clearance shall be as per good and sound engineering practice. Should the owner's representative not consider any material acceptable, it shall be replaced.

1.2.3 Design Features

As far as practicable, all proposed designs shall be as per latest proven concepts and practices. The equipments shall be new, of robust design for long reliable operating life. These shall be capable of 24 hours operation in a day for 365 days in a year for continues operation for prolong period in the climatic and working conditions prevailing at the site and with a minimum of maintenance. Particular attentions shall be given to extra temperature and the rating of electrical and mechanical equipments, cooling systems and choice of the lubricating system.

The equipments shall be designed to provide easy access to and replacement of the component/parts which are subjected to wear without the need to replace whole units. All parts in contact with water/sewage/chemicals shall have a life from new to replacement for 15 year minimum and new to repair of not less than five years. Design features shall include the protection of equipments against damages caused by vermin, dirt, dust and dampness and to reduce the risk of fire. Equipment shall operate without undue vibration.

The noise level produces by any equipment like pump sets, compressor sets, blowers etc., shall not exceed 85 dB(A) measured at a distance of 1.86 m from outer surface of source. At the time of operation, the mechanical vibration shall not exceed the limit given in the **Table 2-1**, at recommended points of the measurement as per ISO 10816:1995.

During the commissioning of the plant/equipments if noise level/vibrations found beyond the permissible limit, contractor to rectify/replace the particular equipment at no extra cost with in mutually agreed time limit. During the O&M period (O&M is done by contractor) if noise/vibration of equipment found beyond the permissible limit, rectify/replace of the particular equipment shall be responsibility of contractor.

Table 2-1 : Permissible Equipment Velocity of vibration (in mm/sec)

Sr. No.	Equipment	Permissible Velocity of Vibration (in mm/sec)
1	All rotating equipment without reciprocating parts of motor rating ≤ 15 kW	1.12
2	All rotating equipment without reciprocating parts of motor rating > 15 kW & ≤ 75 kW	1.8
3	All rotating equipment without reciprocating parts of motor rating > 75 kW	2.8

Parts shall be design to withstand the maximum stresses under the most severe conditions of normal service. All rotating elements shall be dynamically and statically balanced.

1.2.4 Lubrications

The equipment shall be lubricated by long life lubricants such that working life is not less than 3000 operation hours or as per recommendation of the equipment manufacturer.

A complete schedule of recommended oils and other lubricants shall be furnished by the bidder. The number of different types of lubricants should be kept to minimum. The schedule and the name of the supplier of the lubricant shall be submitted to the owner's representative for approval.

Lubricants shall be oil and grease. The contractor shall indicate indigenously available equivalent lubricants with complete specifications.

Where the lubricant is grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Preferably, life lubricated grease packed bearings shall be used. Grease gun for each type of grease used shall be supplied.

1.2.5 Name Plates

Each equipments of the plant shall have permanently attached to it a nameplate and rating plate in a conspicuous position, upon these shall be engraved or stamped, the manufacturer's name, type and serial number of the equipment, details of the loading and duty at which the equipment has been designed to operate, and such diagrams as may be required by the owner's representative. All indicating and operating devices shall securely attach to them or marked upon them designations as to their function and proper manner of use.

1.2.6 Painting

1.2.6.1 At Manufacturer's Work

The contractor shall be responsible for the cleaning, preparation for painting and priming or otherwise protecting, as specified, all parts of the plant/equipment at the place of manufacture prior to packing.

Parts may be cleaned but surface defects should not be filled in before testing at manufacture's work. Parts subjected to hydraulic test shall be tested before any surface treatment. After testing, all surfaces shall be thoroughly cleaned and dried out, if necessary by washing with as approved dewatering fluid prior to surface treatment. Except where the specification provides to the contrary, all painting materials shall be applied in strict accordance with the paint manufacturer's instructions.

Steel and cast iron parts shall be sand blasted to near white cleaning before painting. Edges, sharp corners etc. Shall be grounded to a curve before sand blasting. A primer coat of a zinc rich epoxy resin based coating with at least 75 microns dry film thickness is to be provided. In addition, the parts for wet duty are to be provided with an adequate number of coats of coal tar epoxy polyamine coating to a dry film thickness of 175 microns excluding primer coating.

1.2.6.2 At Site

Immediately on arrival at the site, all items of the plant shall be examined for damage to the paint coat applied at the manufacturer's work. Any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint. After erection, such equipment/items which are not finish painted shall be done so. Items that

have been finished painted at the manufacturer's work shall be touched up for any damaged paint work. Damaged paint during erection shall be made good with similar paint.

For finish painting, two coats of synthetic enamel confirming to IS: 2932 shall be applied. Dry film thickness of each coat shall be at least 25 microns. The dry paint film thickness shall be measured by Elcometer or other instruments approved by the owner's representative. In order to obtain the dry film thickness specified, the contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm².

Painted fabricated steel work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no water or dirt can accumulate on the surface. Suitable packing shall be laid between the stacked materials. Where cover is provided, it shall be ventilated.

1.2.7 Galvanizing

Wherever galvanizing has been specified the hot dip process shall be used and electro galvanized parts, equipments shall not be permitted. The galvanized coating shall be of uniform thickness. Weight of zinc coatings for various applications shall not be less than those indicated below:

- a) Fabricated Steel : 460 gm/m²
- b) Fasteners : 300 gm/m²

Galvanizing shall be carried out, after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminium paint.

1.2.8 Wet Well

- i). In order to prevent surcharging of sewers, the maximum level of sewage in the suction/wet well of the TSPS/ISPS shall be limited to 300 mm below the invert of the lowest incoming sewer.
- ii). For the TSPS/ISPS, in order to prevent sewage from turning septic, maximum retention of sewage in the wet / suction well shall not exceed 30 minutes for the average flow.
- iii). The depth of sump shall be such that it provides at least 15 % margin over the minimum required pump submergence calculated at duty point on the basis of the Hydraulic Institute Standard.

- iv). The wet well effective operating volume (volume between low level where all pumps are shut off and high level where all pumps except standby are operating) shall be such that the hydraulic retention time in this volume at peak flow is not less than 5 minutes and the number of starts per hour does not exceed 6 for any single pump under any circumstances.
- v). Appropriate baffles shall be provided in the wet/suction well to prevent the excessive turbulence and air entrainment when free fall of material to be pumped occurs.
- vi). Benching shall be provided at the bottom of the wet well towards the suction bell mouth to ensure that the pumps can be used to completely drain the wet well. The wet well design shall incorporate corner fillets and ogees as appropriate to eliminate dead spots, prevent accumulation of solids or debris, and to ensure that the wet well is fully self-cleaning – automatically cleaned by the hydraulics of the flow.
- vii). Priming of pumps shall be ensured by providing positive suction head.
- viii). Operation of sewage pumps shall be automatic based on the sewage levels in the wet well.
- ix). Standby unit of each type and size of pump employed shall be provided as specified in particular mechanical requirement and these shall be minimum requirement.
- x). The clearance between pumps outer periphery (or pump foundations) shall be not less than 1000 mm.
- xi). Sequence of operation of raw sewage pumps shall be changed every 8 hours to avoid accumulation of solids in the wet/suction well.
- xii). + 5% margin on the pump capacity shall be provided for all the pumps.
- xiii). The total head of the pump shall be selected considering peak flow and maximum design level in the wet well for normal conditions of operation, and checked for satisfactory operation under extreme conditions of operation; the selected head to be revised if required.
- xiv). The minimum permissible velocity in the pumping mains shall be 0.5 m/sec. The maximum velocity in the pumping main shall not exceed 2 m/sec.
- xv). All dry well pumping stations shall be provided with a pit and drain pumps (1 working + 1 standby) to automatically empty the stuffing box drain.
- xvi). Ventilation shall be provided for the pumping station based on 10-12 air changes per hour.

- xvii). For TSPS/ISPS, mechanical rake coarse bar screen shall be provided upstream of the pumping station wet well. Provisions shall be made to allow lifting of screenings by belt conveyor.
- xviii). Appropriate lifting devices shall be provided for safe and easy retrieval and/or removal of the pumps from wet well or dry well for maintenance or any other purpose at all pumping stations.

1.3 Process Equipments

1.3.1 Mechanically Raked Bar Screen

1.3.1.1 Purpose

- i). Mechanical screens should be suitable for installation in Sewage treatment plant for removal of floating wastes coming along with sewage. These screens should be capable to screen out most of the medium and large floating material such as plastic bags, floating debris, weeds, paper wastes, clothes and rags etc. Which are generally clogging the impellers of the pumps installed downstream of the screens.
- ii). The operation of the screen shall be automatic. An ultrasonic type differential level controller shall be provided to sense the head loss through the bar and give the signal to the travelling raking mechanism to start its operation. The sensor will signal the raking mechanism to operate continuously till the head loss is reduced to a present level.
- iii). A complete electrical control system shall be supplied with each screen and shall be mounted independently near to the screen installation. The system shall provide for total automatic operation of the screen with the feedback from the level controller.

1.3.1.2 General

The screen shall be of the front raking type with aperture size of 60 mm. All the materials and sub-assemblies used shall be suitable for outdoor application. They shall be constructed so that maintenance is kept to a minimum. There shall not be any moving part, sprocket, bearing, etc. Continuously immersed in sewage. All lubricating points shall be conveniently accessible from the deck level.

The screen shall be suitable for discharging 75% of the screened material lifted from the screen in to chute. The screen shall be designed such that in case of heavy accumulation of solids, the same is to be removed gradually without overloading or damaging the screen bars or mechanism.

1.3.1.3 Scope

- i). Contractor shall furnish and install mechanically cleaned bar screens with multiple rake blades. Each screen shall be manufactured from SS 316 stainless steel shapes. Fabrication and assembly shall be in conformance with this specification.
- ii). Each screen shall be furnished complete with bar rack, dead plate, discharge chute, side frames, covers, rake blades, drive chains, sprockets and bearings , scraper assembly, drive motor, gear reducer, anchor bolts, controls and all accessories and appurtenances specified or otherwise required for complete and properly operating installation.
- iii). Contractor shall coordinate all details of the equipment with other related parts of the work. He shall verify that all structures, piping, wiring, and equipment components are compatible. Contractor shall be responsible for all structural and other alternations required to accommodate equipment differing in dimensions or other characteristics from these specifications and drawings.
- iv). Contractor shall install the equipment according to instructions and recommendations of the equipment manufacturer.
- v). Power supply is 400Volts, 50Hz, 3-phase.

1.3.1.4 Material

- i). Screen shall be manufactured from AISI 316 stainless steel shapes (rods, angles, and channels), pipes and sheets. In particular, side frames and guides, bar rack, rake assembly, scraper assembly, shafting, discharge chute, fasteners and anchor bolts shall be made of this material.
- ii). Screen shall be manufactured in a stainless steel factory only to prevent contamination of the stainless steel with rusty dust.
- iii). All stainless steel components and structures shall be submersed in a chemical bath of nitric acid and hydrofluoric acid (pickling bath) to remove any residues that may be present on the material as a result of forming, manufacture, or handling. After removal from the pickling bath, the equipment must be washed with a high-pressure wash of cold water to remove any remaining surface debris and promote the formation of an oxidized passive layer which is critical to the long life of the stainless steel.
- iv). Chains and sprockets shall be made of SS 316.
- v). Lower sprocket bearing shall have a stainless steel casing including a shaft made of white cast iron and a ceramic (calcium carbide) friction bushing.

- vi). Upper sprocket bearings shall have a paint coated cast iron casing and include ball bearings that are greased for life and shall be double-sealed with Nilos rings.

1.3.1.5 Performance & Design Requirements

- i). Separation of floating, settling and suspended material from wastewater by means of an inclined bar rack installed within the channel.
- ii). Both ends of the cleaning elements are connected to drive chains.
- iii). Each chain is driven by a sprocket on a common shaft and a flange mounted gear motor.
- iv). Furthermore, defined meshing of the cleaning rakes with bar rack ensures a high operating reliability.
- v). The cleaning elements, attached to the chain system, should be adjustable.
- vi). The cleaning elements, consisting of the rake and comb plate, are screwed and thus independently replaceable.
- vii). If the screen operation is blocked, the electromechanical torque control reliably protects the screen against damage caused by overload.

1.3.1.6 Frame work

The frame work of the screen should be such that it should mount on the top of the channel wall. Screen construction should be such that, it should mount only on top of the channel wall. The frame will rest on the special supports installed on the wall along the depth of channel. In case of maintenance, screen should be able to be lifted out from the top with crane. No personnel should go inside the screen chamber for any type of maintenance or repair work.

1.3.1.7 Screens Construction

- i). The bar Screen shall remove floating materials from the incoming wastewater by means of a positively cleaned bar rack that is installed in a concrete channel. The screen shall retain floating materials at the bar rack.
- ii). A multitude of rake blades shall remove and lift the floating materials to a discharge mechanism.
- iii). The bar rack shall be cleaned by a serious rakes engaging the bar rack from the upstream side at the bottom of the channel and then moving up along the bar rack.

- iv). The floating materials shall be lifted above the channel and dropped on a discharge chute at the downstream side of the screen.
- v). Screens with single rakes shall not be approved.
- vi). The bar rack shall consist of equally spaced, straight bars that are inclined from the horizontal with the inclination angle specified above.
- vii). The lower ends of the bars shall be provided with a minimum 4 mm thick curved base plate such that the rakes positively remove all screenings from the bottom of the bar rack.
- viii). Bars shall have Tear Drop profile with a cross section of 12 mm(front width/Tear Dia) X 10 mm(back Width) X 50 mm (Depth).
- ix). The bar rack shall be securely fastened to the frame of screen and be readily removable.
- x). The bar screen shall be provided with a dead plate extending from the bar rack to the discharge chute.
- xi). The dead plate shall be made of a minimum or 4 mm thick stainless steel plate and shall be stiffened by structural members so that it is flat without undulation so that the tips of the rake's teeth ride at a distance between 1 to 2 mm over the dead plate.
- xii). The dead plate shall be securely fastened to the side frames.
- xiii). A Discharge chute shall be provided that fully encloses the discharge section of the screen. An access hatch with hinges and a handle shall be provided in the chute permitting easy access. The discharge chute shall be mounted to direct screenings into the appropriate receiving container or conveyor.
- xiv). The chute shall have a slope of minimum 45 degrees. The discharge chute shall be made of a minimum 4 mm thick stainless steel plate.
- xv). A frame shall be provided supporting all required loads. Side frames shall be made of 4 mm thick 316 stainless steel plates with a minimum of four axial edges. The side frames shall be connected with each other through channels having a minimum thickness of 4 mm and a minimum cross section of 108 X 49 mm. The side frames shall be connected to support frames. The support frames shall be securely anchored onto the operating floor.
- xvi). The screen shall be provided with easily removable, sufficiently, stiffened covers made of 1.5 mm thick stainless steel plates with edges on all sided. The covers shall be provided with turn locks and handles.

- xvii). Each side frame shall include separate roller tracks to guide the rakes. The roller tracks shall be bolted to the frame so that they can easily be replaced. The roller tracks shall be made of 4 mm thick L-profiles
- xviii). Drive chains for the rakes shall be roller type chains and be made of hardened steel and shall be zinc and chrome electroplated.
- xix). Each chain shall have strength of 125 kN. Drive chains, chain guides, sprockets and their bearings shall be replaceable without removing the screen from the channel.
- xx). Chains rollers shall be made of polyamide and shall have a diameter of 70 mm and shall be a minimum of 32 mm wide.
- xxi). The sprockets shall be made of minimum 29 mm thick hardened steel plates and shall be Zinc galvanized and chrome plated. Rakes shall include rake bars made of 6 mm thick channel profile having a cross section of 105 x 60 mm.
- xxii). The rake blades shall have teeth matching and engaging the bars of the bar rack. The rake blades shall each consist of several pieces with teeth such that only one piece needs to be replaced in case that a tooth should be damaged.
- xxiii). A pivoting scraper mechanism shall be positioned at the point of discharge and shall be attached to the side frames. The scraper shall clean the rake on each pass and return to its rest position with minimal shock. The scraper shall be designed such that screenings do not wrap around the rake or scraper. The scraper shall be provided with a scraper bar made 4 mm thick channel profile with a minimum cross section 39 x 68 mm and an adjustable 10 mm thick wiper made of polyethylene. The scraper shall be connected with the frame through a pair of minimum 500 mm long scraper arms that shall be made of 4 mm thick channel profile with a minimum cross section 68 x 59 mm.
- xxiv). A pair of shock absorber elements made of neoprene shall be provided.
- xxv). The drive shaft shall have a diameter of minimum 80 mm and a wall thickness of minimum 5 mm.
- xxvi). The drive shaft includes an integral rocker arm assembly on the drive end that flexes if the screen rakes get jammed.
- xxvii). The rocker arm assembly shall consist of a drive unit mounted to a stainless steel arm. The stainless steel arm will be held in place by a flanged roller bearing connected to the drive shaft and two heavy duty tension springs. The flange bearing shall be connected to the rocker arm by four bolts. The rocker arm shall be maintained in the standard operating position by the two tension springs. If the screen rakes experience a jam, the force will cause the rocker arm to rotate around the drive shaft, compressing one of the tension springs. This motion shall be limited

by a rocker guide. When the rocker arm rotates out of the normal operating position a proximity sensor will send a signal to the PLC causing the motor to enter a self cleaning mode. If the self clearing mode should prove unsuccessful then the system shall initiate an alarm signal.

- xxviii). All stainless steel parts must be completely passivated and submerged fully in Pickling Bath.
- xxix). Rake screen must be full flexible to make the cleaning frequency to the requirements on site. To do so, the quantity of rakes installed on the screens. The quantity of rakes can be increased to meet the necessary screenings conveying capacity.
- xxx). Motor can be equipped to run on frequency converters; therefore can adjust the speed of the rakes to meet the necessary screenings conveying capacity.
- xxxi). Rake screen must be using stainless steel covers as a standard.
- xxxii). Rake screen bar rack is put together with segments. A segment has a higher stiffness instead a single bar. In case of damage, only the damaged segment has to be changed, not the whole bars rack.
- xxxiii). Rake screen should be with front rake system with no of rakes should be minimum 8 considering channel depth

1.3.1.8 Screen Drive

- i). Bauer or equivalent make of TEFC motor with protection grade IP 65.
- ii). Explosion protection in accordance with II2GExellT3

1.3.1.9 Control & Instrumentation

The screen shall be pre-wired so that the tenderer is only required to make electrical connections to the control panel and from the control panel to a junction box at the screen.

Local control on Screen:

- i). One proximity switch for monitoring of the rocker arm position.
- ii). One local control station.

1.1.1.1 Water Level Sensors

Tenderer shall provide one transducer and electronics package for continuously monitoring of the upstream water levels for control of screen operation. The transducer shall be rated for hazardous locations and shall be intrinsically safe without the use of additional barriers, complete with built-in temperature compensation and submerged shield. The transmitter shall be mounted in the control panel. Tenderer shall install the transducers and provide wiring to the control panel.

1.3.1.10 Control Panel

- i). A single main control panel shall be furnished with a lockable corrosion- resistant stainless steel enclosure together with 8 local push button stations rated for a hazardous environment.
- ii). Control panel shall contain all power and control devices necessary for the proper function of the screen.

1.3.1.11 Shop Testing

- i). The screen shall be factory assembled and subjected to following tests at manufacture's premises.
- ii). Dimensional check: The overall dimension of the screen shall be confirming to the approved drawings.
- iii). Operational Test: The Complete screen including its carriage, rake, drive system and brake motor shall be mechanically operated and tested to verify interference free movement and satisfactory operation.

1.3.1.12 Inspections & Tests

- i). The Purchaser & its representative shall have the right to inspect and / or to test the Goods (major equipments as specified in scope of work) to confirm their conformity to the Contract. The special conditions of contract and / or the Technical Specification shall specify what inspections and tests the Purchaser requires and where they are to be conducted.
- ii). The Purchaser shall notify the Supplier in writing of the identifying of any representatives retained for these purposes. All the expenses related to inspection at manufacturer's works & at site viz. Lodging & boarding, transportation; all facilities including third party inspection (TPI) fees and other related commercial expanses as and where required shall be borne by the successful bidder.

- iii). Offered items for testing at manufacturer's premises & at site shall be done by third party inspection and owner's (client's) representative deputed by purchasers.
- iv). Also major equipments as specified in Scope of Work shall be tested at manufacturer's works. The inspections and tests may be conducted on the premises of the Supplier or its subcontractor(s), at point of delivery and / or at the Good's final destination.
- v). Should any inspected or tested Goods fail to conform to the Specifications, the Purchaser may reject them and the Supplier shall either replace the rejected Goods or make all alterations necessary to meet specification requirements free of cost to the Purchaser.
- vi). The bidder shall be responsible for communication & co-ordination between all supplier for the compatibility of the various electrical & mechanical equipments. The Purchaser's right to inspect, test and, where necessary, reject the Goods after the Good's arrival in India shall in no way be limited or waived by reason of the Goods having previously been inspected, tested and passed by the Purchaser or its representative prior to the Goods' shipment from the country of origin.

Approval of Documents:- It will be in the scope and responsibility of the Contractor to get the documents(drawing and data sheet) approved by the client prior to manufacture.

1.3.1.13 Conveyor System

For the disposal of screenings, a motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects, which may cause shock loads. The capacity of the conveyor shall be in accordance with the peak flow.

The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of maximum 20 deg. Trough type complete with drive assembly structures, idlers, pulleys and belt cleaners/Scrapers. Idlers and pulleys shall be provided with anti-friction bearings.

The belt material shall be three-ply nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journaled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity.

The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide pre-stressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment of ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying side and 2400 mm on return run.

The width of the belt shall be minimum of 600 mm and speed of the belt shall be between 18-20 metre per minutes.

The head and tail pulleys shall be manufactured from welded steel/ alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings.

Shafting for pulleys shall be of heat-treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided anti friction bearings.

The belt conveyor shall be driven by a squirrel cage, TEFC motor coupled to the reduction gears. The gears shall have service factor of 2. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have backstops to prevent backward movement of the belt.

The conveyor shall be supported on 150 mm channel section with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.

An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fibreglass/ fibre reinforced plastic/ PVC.

The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. Belt sway switches shall be provided on conveyor.

Screening discharge chutes (Galvanized MS made) shall be provided to transfer screening from the screen to the conveyor and from conveyor to Portable screening container. The discharge chute of conveyor shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chute shall be design to minimize the accumulation of rags and stringy materials.

1.3.1.14 Portable Screening container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up/ The container shall have capacity of approximate 2.0 cu.m and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The container shall have hinged covers and its design shall permit their being lifted by an overhead hoist or packer truck. The container shall be trolley type attachable to tractor. The sides shall be constructed of 12-gauge steel. The bottom of container shall be made of 5 mm steel plate.

The containers shall be reinforced with 50 mm x 50 mm x 5mm angle.

1.3.2 Manual Coarse Screen

Screens shall have opening not more than 20mm, to prevent coarse debris from entering the inlets and protect the plant against mechanical damage. They shall be inclined at an angle of not less than 90 degrees from vertical to facilitate raking.

The design shall avoid the formation of areas of stagnation in the flow. Sealing shall be provided between the frame and the inlet channel walls.

Screens shall be designed to withstand the maximum possible pressure differential across the screen when fully blinded, without incurring any damage or overload. The working head loss across the screen at maximum flow shall not exceed 50 mm following screen cleaning. Unless otherwise specified the velocity of the flow through the screen shall not exceed 1.2 m/s.

The equipment shall be capable of operation under all duty flow variations and debris loadings, and shall be capable of withstanding the impact of large floating material and heavy objects in the flow without damage to the screen.

Screen bars shall be accurately set and secured to give the designed clearance between the bars. The bars shall extend from the sole plate, to which they shall be individually welded, to a point above maximum possible top water level, at which point they shall be individually welded to the screen top plate. Intermediate stiffening supports shall be welded to the screen bars as necessary for screens to accommodate hydraulic pressure due to depth and high flow rates through the inlet channels. The screen bars shall be individually welded to each stiffening support. Stiffening supports shall be fitted so they cannot impede raking. Sole plate shall be profiled to induce screenings and debris to be directed onto the screen bars and not to accumulate at the foot of the screen. The leading edge of the sole plate shall be level with the inlet channel invert.

The top edge of the screen shall be profiled to enable easy raking-off of screenings material.

When specified, for applications where large or heavy oversize debris may accumulate against the screen, hoisting equipment shall be provided. The screen shall then be fitted with hoist-guide pulleys, and operator access shall be provided to enable manual removal of oversize objects from the flow.

Screens shall be constructed from SS 316.

Raking shall be manual and screenings shall be transferred manually to a rakings container. The scope of supply shall include manual rakes and manually moved containers, with all accessories needed to remove the collected debris.

Rake tines shall be designed to fit the screen apertures, and tines shall be of material which cannot damage the screens. Rakings containers shall be sized so that, when fully loaded with the typical tropical organic material expected, the gross weight shall not exceed 50kg. They shall be fitted with handles to facilitate manual or mechanical handling.

1.3.3 Mechanical Fine Band (Escalator)/Perforated Plate Screen

1.3.3.1 General

- i). The fine band (Escalator)/Perforated Plate screen shall consist of continuously moving perforated stainless steel panels.
- ii). The machine shall be arranged to pivot out the channel.
- iii). The aperture size shall be 6 mm.

1.3.3.2 Construction

- i). Self-supporting stainless steel construction with attached screenings chamber for reception of the brush roller, including maintenance-free flange bearing.
- ii). The screening elements are perforated plate filter baskets, partly equipped with rake bars.
- iii). Each end of the perforated plates is connected with a drive chain that is driven by chain wheels. Each chain is driven by a sprocket on a common shaft and a flange mounted gear motor.
- iv). At their upper turning point the perforated plates are continuously cleaned by a fast counterrotating brush which increases the cleaning energy and thus significantly improves the cleaning efficiency.
- v). Cleanising is supported by an integrated spray bar.

- vi). The sturdy perforated plate screen is able to reliably cope with even high amounts of gravel and grit.
- vii). The two-dimensional screening elements prevent especially long fibres from passing through the screen and achieve thus the maximum separation efficiency.
- viii). Formation of screenings rolls is prevented by rake bars extending over the full width of the screen in combination with the screen's installation angle. Even cans and bottles are lifted by these rakes.
- ix). Counter rotating brush roller for removal of screenings from the trough edge so that no additional scraper roller is required for trough edge cleaning.
- x). Wear-resistant plastic elements ensure proper sealing between the travelling screening elements and the frame whilst the perforated plates are moving.
- xi). The connection between the plastic and screening elements is designed to allow quick and easy replacement.
 - 1. Internal spray nozzle bar
 - 2. Wash water connection: Storz C coupling,
 - 3. Required washing pressure: 4-5 bar;
 - 4. Washing medium: service water (particle size < 200 µm)
- xii). Activation via the solenoid valve of the customer's wash water supply unit.
- xiii). Bushed conveyor chains each deflected by two upper and lower chain wheels and guided in lateral profiles.
- xiv). Guiding tracks with required connecting profiles for reception of the jack-to-jack chains
 - i. Chain wheel bearings:
 - ii. Regreasable upper flange bearings
 - iii. Wear-resistant, maintenance free lower ceramic bearings
- xv). Upper chain tensioning unit, easy to access from outside
- xvi). Completely odour-encased screen with easy to remove covers.
- xvii). The machine should be suitable to be used in zone 1 hazardous areas.

Screen Panels: Minimum 3 mm thick panels of SS 316 construction shall incorporate 6 mm diameter perforations. These panels shall be carried on the chains. The Panels shall be specially formed to give a very rigid construction and shall create steps to enable larger screenings to be removed.

Seals: Polypropylene sealing brushes shall be incorporated at each side and across the bottom of the screen to prevent screenings from by-passing the screen panels.

1.3.3.3 Screenings Discharge

- i). Screenings shall be discharged on the downstream side of the unit and shall be removed from the screen panels by a heavy duty rotating brush. The brush material shall be polypropylene.
- ii). Screenings are delivered down an enclosed chute.
- iii). Two nos. Screening collection containers (wheeled) of suitable capacity shall be supplied with the screens.

1.3.3.4 Enclosure

The entire assembly shall be enclosed in reinforced fibre glass housing. A hinged front cover shall be provided to give access to the rotating brush assembly and screen discharge area. A Sliding inspection hatch shall also be incorporated.

1.3.3.5 Drive Unit

- i). The drive to the main shaft shall be TEFC weatherproof IP 55 motor fitted with an anti-condensation heater and shall be suitable for operation on 415 V + 10% and frequency of 50 Hz + 5%. The motor shall be flanged to a shaft mounted gear unit giving the final output speed. This shall produce a linear speed for screen panels of about 3 m/min.
- ii). The drive shall be protected from mechanical overload by an electrical current sensing device in the screen control panel.
- iii). Differential pressure switches shall be provided to annunciate screen jamming.
- iv). Suitable conveyor arrangement shall be provided to transfer the screening to the nearest container/trailer.
- v). A spray system shall be provided to backwash the screen panels and to help in cleaning the screenings. Water/treated sewage shall be used for the back wash purpose.

1.3.3.6 Control Panel

The control panel shall have IP 55 protection, painted with Epoxy paint and shall be comprising of

- i). Mushroom Headed Emergency stop
- ii). Overload relays for motor protection

- iii). MCB's, HRC fuses and Glass Fuses
- iv). Circuitry to operate the screen with level sensor
- v). Selector Switch to operate the screen on JOG mode.

1.3.4 Manual Fine Screen

The manual bar screen will be of opening not more than 10 mm. Hand rake shall be provided with manual screen for cleaning of screen. The screen shall be rectangular in shape. The screen shall be fabricated out of stainless steel SS 316 of not less than 6 mm thick and 50 mm wide in section. The screen shall be rigidly fixed to the frame and provided with 2 sets of cleaning rakes.

1.3.5 Grit Removing Equipment- Detritor, Vortex and aerated type

For STP initially the sewage shall be subjected to pre-treatment which includes removal of floating material through screen and grits with the help of grit removal mechanism. From the inlet chamber, the sewage will overflow to screen chambers, each screen channel comprising of mechanical fine perforated plate screen suitable for design peak flow shall be provided. Perforated plate screens shall be provided for removal of floating materials, etc. Shall be provided in each screen channel. After screening, the sewage shall overflow to grit chambers for removal and washing of grits from the sewage. Each grit chamber shall have grit separating system and grit washing system. The grit will be collected and transferred to the collector via screw conveyor

Grit chamber

The flow from the screen channel shall be allowed into the grit chamber for the removal of grit/inorganic matter by means of RCC tank designed as per relevant is code of practice.

There shall be 2 no. grit chambers. Grit chambers shall be designed for peak + other flow. Mechanical grit chamber shall be capable of removing grit of particle size of 100 micron and above and sp. Gravity of 2.65.

The surface loading rate, settling velocity and other design parameters shall be as stated earlier. The grit chamber shall be of RCC M30 grade construction with suitable RCC foundation with necessary water tightness test.

The inside surface of the grit chamber shall be provided with 20 mm thick water proof plaster in cement mortar 1:3. The bottom of the chamber shall be provided with 40 mm thick ips screeding. The outside surface shall be provided with 20 mm thick double coat sand faced plaster in cement mortar 1:3 with exterior emulsion as per civil specification.

Chamber should be curved the vortex in shape. the mechanical grit chamber shall be of curved vortex type so the screened wastewater enters at the bottom of the grit chamber will rotate tangentially.

The grit chamber shall be equipped with constantly rotating stirrer which helps the wastewater circulation within the grit chamber ensuring a constant velocity of rotation within the complete grit trap system even under dry weather conditions.

Due to the constant radial rotation the solids are very quickly collected within the centre of the grit chamber from where they then pass into the bottom of the grit collection tank.

The grit-free wastewater then exits and flows onto the next treatment step.

Centrifugal or airlift pumps can then deliver the collected solids from the grit collection tank into a grit classifier or grit washer where the solids can then be subsequently separated and dewatered and organic particles removed.

Mechanism

Turning drive shaft, driven by the bull gear, material 1.4307 (316) or better.

4 pcs. Stainless steel paddles with hard cast iron welding, fixed on the drive shaft. The paddles should be adjustable in all directions, interlocked with counter screws.

Central tubing prearranged for air lift pump with funnel in the grit discharge area.

The central shaft is ending with a flange. Removable floor plate over grit storage chamber with minimum opening 75 mm to storage chamber, design plate assembly in two sections with lifting lugs, plate thickness minimum 10 mm.

Totally enclosed squirrel cage motor with at least ip55 protection in accordance to vdi/iso standards.

Gear reducer to include anti-friction bearings with high overhung load properties, and double lip oil seals. Drive unit and motor bearings have a minimum bearing life of 100.000 hours.

Turnable bearings supporting the paddles assembly have a minimum bearing life of 20 years. Grit from grit washing unit should be guided with the help of screw conveyor to the grit collector.

DEGRITING TANK MECHANISM, CLASSIFIER AND WASHING OF GRIT

Removing different type of grit, clay, sand, metal etc. From tank mechanism, classifier and washing of grit etc.

It shall incorporate following.

- i). Removing different type of grit, clay, sand, metal etc. From tank mechanism:
- ii). The different type of grit, clay, sand, metal etc. Settled in a tank shall be scrapped a collection point by a scrapper mechanism.
- iii). It shall be designed for continuous operation. The mechanism will be coupled to a suitable motor-gear- box assembly.
- iv). The collected grit shall be elevated to the top of tank by the help of a classifier. While the grit is being elevated from the tank bottom, suitable arrangement for grit washing by plain tap water shall be made.
- v). All moving parts shall be abrasion resistant.

GRIT WASHER

The grit mechanism will be suitable for installation in a round tank and will comprise of the following:

Grit collection mechanism.

Organic return pump.

Classifier cum washing mechanism.

The grit contained in waste water is usually removed in grit traps by gravity or centrifuge force to protect downstream equipment.

FUNCTION

No additional screening must take place upstream of the grit washer. The plant must be able to handle mineral grain sizes up to 30 mm.

The grit/water mix must centrally flow into the grit washer.

Grit classification and washing must take place in one tank, i.e. preceding longitudinal grit traps are not permitted.

- i). Surface overflow rate (incl. Wash water) must be $< 25 \text{ m/h}$.
- ii). The grit washer must be equipped with an circumferential overfall weir on the outside.
- iii). Overflow weir load must be $< 15 \text{ m}^2/\text{h}$.
- iv). The combined addition of water and air or fixed bed plants are not permitted.
- v). The grit washer must have a separate organics discharge $\geq \text{dn } 100$.

- vi). The grit washer must have a clogging-free perforated membrane sandwich-plate at the lowest point of the wash cylinder for best water distribution in order to achieve best wash results.
- vii). Grit level measurement must be carried out by means of a hydrostatic pressure probe.
- viii). The grit washer must remain in full function (wash and discharge grit) even during feeding from the grit trap.
- ix). The grit removal screw must be a stainless steel screw supported on both ends.
- x). Shaftless spirals or screws made of “special steel” are not permitted.
- xi). The grit removal screw trough must not have guide bars or plastic shells.
- xii). The grit washer must be acid treated in a pickling bath and passivated
- xiii). The complete grit washer must be made of at least 1.4307 stainless steel material.
- xiv). The stirrer must be made of at least 1.4307 full stainless steel material ≥ 30 .

Grit washer

- i). The grit washing machine should achieve high grit separation efficiency through optimum utilization of the tank volume due to the defined and calculable flow path based on the coanda effect in the inlet combined with the preceding vortex chamber.
- ii). After solids separation the organic particles are washed out in the bottom part of the tank by means of a grit fluidized bed.
- iii). The wash water is added across the entire wash zone cross section. To achieve constant washing results, the system should work with an uniform, constant upflow velocity in the wash zone.
- iv). Washout is supported by a slowly running stirrer. As a result, the lighter organic particles are separated from the dense mineral particles.
- v). Organic material should be additionally removed via a separate automatically actuated organics discharge located above the grit fluidized bed.
- vi). The washed grit should be removed and at the same time dewatered by a sturdy grit transport screw supported on both ends in a trough. There should be special arrangement of the screw flights for plug-free operation. The screw should be impulse-pause operated in dependence of the fed amount of grit, which is measured by a pressure probe.
- vii). Organic loss should be less than 3%

1.3.5.1 Classifier Mechanism

The classifier mechanism shall comprise of a screw driven by a suitable motor. The material of construction of the mechanism shall be SS 316 and the diameter shall be minimum 400 mm. The length of screw shall be such that the grit can be elevated up to the discharge end. SS puddle pipe shall be provided in the concrete trough at the discharge point of wet grit.

Classifier Mechanism: The mechanism shall consist of the following:

- i). Chain and sprocket with guard.
- ii). Reciprocating rake with hangers of screw mechanism.
- iii). A.C. Motor.
- iv). Local push button shall be provided.

1.3.5.2 Organic return Pump

Vertical Propeller pump with suitable motor, starter, etc. Shall be provided. The design of the pump and the piping on the inlet and outlet side has to be such that there are minimum numbers of bends as they are liable to be choked with organic matter.

One set of push button shall be provided near the pump set and one starter in the terminal sewage pumping station. The suspended organic matter washed in the de-gritting system will be returned to the distribution chamber. Impeller shall be of SS CF8M and shaft shall be of SS 316.

In the event of tripping of working grit removing equipment (motor), the sizing of this equipment (including motor) shall be done in such a way that it shall take the overhead to remove the excess grit collected after starting of the tripped grit removal equipment.

1.3.6 Primary & Secondary Clarifiers

Circular (radial), fixed bridge with scum collector, central turns table type or peripheral drive type, collecting effectively with proper circumferential speed, clarifiers shall be provided. The clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

- (a) The drive head mechanism arrangements shall consist of a turn table base casing mounted on top of the centre pier and shall have an angular ball bearing mounted internal gear that supports the underwater mechanism. The pinion meshing with the internal gear should be driven through a worm gear reduction unit mounted on top of the turn table drive unit. The balls should ride on hardened steel strips set into grooves in the base and gear casing so that they can be readily replaced whenever required.
- (b) The unit will have mechanical overload arrangement with a torque indicating arrangement along with necessary contacts for tripping the motor in the event of overloading. This condition shall be enunciated. The unit shall have push button station near the motor and starter with push button shall be provided in the control room, i.e. the return activated sludge pump house along with necessary switches.

The clarifier unit should also be provided with necessary M.S. scum trough, scum baffles, skimmer assembly, M.S. rake blades, arms and brass squeezes. The V-notch weirs shall be 6mm thick of reinforced fiber glass with clamps etc. For making the necessary adjustments.

- (c) The bridge connecting the periphery of the tank to centre pier shall have walkway covered with chequered plates and provided with hand railing on both sides.
- (d) Corrosion allowance of 2mm shall be taken in the structural sections of scraper arm, bridge etc.

Structural design calculations shall be submitted for all structures including scraper arm, bridge, Support system for MBBR media, MBR membranes etc.

1.3.7 Decanter Assembly

(a) Decanter Assembly

Mechanical floating/swing down decanter and related equipment accessories as described herein for each basin. Each decanter shall consist of an integral flotation unit, a stainless steel movable weir assembly, and an electric motor-driven actuator to open and close the weir.

(b) Performance

Each decanter shall be capable of withdrawing decant fluid beneath the liquid surface, regardless of liquid depth, down to the minimum allowable water level. The decant liquid shall be drawn through an adjustable weir. The weir shall be circular in shape and permit liquid to enter the decanter from the entire 360 degrees without obstruction or equivalent.

(c) Weir Actuator

Weir actuator shall include a reversible electric motor operated linear actuator. The actuator shall be capable of operating with a closing force and shall operate from a 415 volt, single phase, 50 hertz source. Adjustable limit switches shall be included to permit adjustment of the weir opening. A spring shall be included to provide for travel after the weir has closed and provide desired closure pressure. A corrosion resistant removable cover shall be included to provide protection to the actuator and motor during normal operation. The power section is painted steel. Power cable shall be provided from the NEMA 4X junction box of the unit to the basin wall. Supply of junction box/disconnect at the basin wall shall be the responsibility of the installing contractor.

(d) Weir

The weir shall be constructed of 316 stainless steel, be circular or rectangular in shape, and shall include vortex control baffles permanently affixed to the weir. The weir shall be attached to the actuator through a removable single shaft or linkage which shall also function as the torque restraint.

(e) Flootation

Each unit shall be equipped with a modular float constructed of fiber reinforced polyester filled with closed cell polyurethane foam having a minimum 2.0 lbs./ft³ density. Float shall be completely sealed to prevent the foam from being in contact with the external environment. Float shall have appropriate eight reserve buoyancy to ensure stability and to provide support flotation required during decanter servicing. A urethane type or equivalent seal shall be molded into the bottom of the float assembly to receive the decanter weir.

(f) Decanter Discharge Pipe

Each decanter shall include a 316 stainless steel elbow flange and 316 stainless steel flanged flexible joints and others. The installing contractor shall provide a valve with hose bib connection on the decant line between the decanter and the decant valve.

All piping, supports, gaskets, and hardware beyond the terminating flange of the decant pipe flexible joint shall be supplied by the installing contractor.

(g) Decanter Restrained Mooring System

Each decanter shall include a stainless steel mooring frame attached to the float. Stainless steel mooring post assembly with base plate shall be provided to assure consistent location of the decanter in the basin. Mooring post shall be filled with concrete by the installing contractor.

Stainless steel dewatering support posts consisting of vertical pylons with base plates and pipe dewatering support post with pipe saddle and base plate shall be provided. Each support with base plate shall be affixed to the basin floor with 316 stainless steel adhesive anchors. Top and bottom mooring post supports constructed of stainless steel shall be provided for attachment to the basin wall by the installing contractor.

(h) Decant Flow Control Valve

Furnish one electrically operated butterfly valve for each basin to control the decant rate.

Valves shall be electrically operated butterfly valves with ANSI Class 125# flanged end ASTM A-536 ductile iron body, ductile iron disk with a 316 stainless steel edge, fully lined EPDM seat vulcanized in the body, 316 stainless steel shaft assembled and tested with 415 volt, three phase, 50 cycle open/close service electric actuator. Valve actuator shall include a compartment heater. Each valve shall include a manual override with limit switch feedback

to the microprocessor in both the open and closed positions. Field wiring and junction/box disconnect shall be provided by the installing contractor.

The bidders are encouraged to propose alternative type and design of Decanters with proven technology and successful operation for last 5 years and minimum 15 number of installations.

1.3.8 Diffused Air Aeration system

This section of the specification sets out the minimum requirements of the design and selection of diffused air aeration system equipment.

- i). The pipe works, instrumentation and the diffusers shall be correctly sized to deliver the required quantity of air at the available pressure to meet all operating conditions. The pipe work to the tank shall be sized for 125% of the required oxygen transfer capacity to cater for the higher loadings.
- ii). The aeration header shall be design for removal/replacement from/to the reactor without taking the reactor off-line or dewatering the reactor. The operator shall be required to demonstrate removal and replacement of the headers with the reactor on-line.

The Blowers shall be provided for providing adequate oxygen into the reactor tank for aeration. The blowers shall be capable of developing the required total pressure at the process unit rated capacity for continuous operation. The blowers shall be Twin Lobe type preferably.

1.3.8.1 Air Blowers

Following specification to be considered

- a) The blower shall be of single-stage centrifugal, and shall be designed integral type. The flow rate should be adjustable by controlling the rotation speed with frequency converter or inlet vane or discharge guide vane according to the inlet temperature and differential pressure to ensure the optimal power consumption. Regulation should be possible in the range of 100-50% of the specified design flows at all project design temperatures and at design pressures.
- b) The regulation should be fully automated and contain a program for continuous optimization of blower efficiency with respect to changes in inlet temperature, differential pressure and required flow.

- c) The pressure grade of the blower casing shall be minimum PN10. The casing shall be cast and bolted together and allow the impeller to be removed with the casing in situ.
- d) The impeller shall be open radial flow type (with backward leaning) and made of aluminium alloy, all surface of the vanes should be finish machining.
- e) High frequency, variable rotation speed and air-cooling motor should be adopted. The impeller and cooling fan should be directly connected with the motor shaft.
- f) The motor shall be equipped with magnetic bearings (If required), which should have the characteristic of magnetic suspension and continuous variable rotation speed. The motor should be installed at a frame with flexible fastening devices.
- g) Two radial magnetic bearings and one axial magnetic bearing shall be orientated accurately via the active-bearing controller controlling the rotor. The active bearing controller shall be powered by one DC and one 3 phase AC input. The service life of all bearings should be more than 100000 hours.
- 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 fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers.
- i) The local control cabinet should be equipped with display screen and keypad unit. The running state of the blower should be able to monitor at real time. The displayed data at least include the following:
 - Actual flow (%)
 - Running time (hour)
 - Running time (day)
 - MWh counter
 - Differential pressure
 - Reference flow (%)
 - Model of the blower
 - Power frequency of the motor (Hz)
 - Current (A)
 - Transition temperature
 - Motor temperature
- j) When operating, if the control system finds fault, the blower will give an alarm automatically or stop and the fault code will be displayed at the control cabinet. All signals can be transferred to the control centre of the plant.
- k) The blower should have the following protection functions (but not limited to):

- Over voltage of the main power supply
- Under voltage of the main power supply
- I-phase fault
- Over voltage/Under voltage of the auxiliary power supply
- Inlet and outlet air pipe blocking
- Air temperature is higher than the specified limited temperature
- Cooling air temperature is high than the specified limited temperature

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 stainless 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 Bellows joint of SS316. 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 stainless 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 operator shall be motorized, equipped with open/closed limit switches, and shall be suitable for air service at 200°C operating temperature. Controls for the valve shall be mounted in each local blower control cabinet with indicating light.

e) Blow-off silencer:

Blow-off silencer shall be provided for each blower and mounted on the discharge bypass line. The blow-off valve silencer shall be constructed of stainless 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.

f) Discharge check valve (Back-flow Barrier) :

Each blower shall be provided with one discharge check valve flange ends located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1/BS: 4504 or Eq. 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.

g) Noise Protection Cover:

The blower and motor should be covered with one Acoustic cover, which should be equipped with electric cooling ventilator.

h) 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:

Description	Material of Construction
Blower Housing	Ductile (SG) Iron IS 1865 Gr.500/7 or Superior grade
Impeller	Aluminium alloy
Shaft	SS410
Base plate	Profiled steel
Inlet filter, silencer casing	SS 304
Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
Blow-off silencer and motor cooling silencer	SS 304
Inlet cone extension	SS 304
All connecting accessories and	AISI 316

Description	Material of Construction
anchor bolts	

Control

The control system of the blower should be well connected with the control system of the whole plant. All the real time monitor and protection function shall connect with the control software; the remote control shall be carried out with 4-20 mA or network.

Local control panel and control cabinet shall be combined, that include display screen and keypad, main switch and lock stop push button. The blower operation shall be controlled by the main running switch and keypad.

Performance Guarantee:

The Performance of the compressor shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%.

Compressor or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

1.3.8.1.1 General Design Requirements

- i). The air blowers shall be such design as to achieve energy efficient operation continuously over the range of design airflow rates at the discharge pressure that shall remain practically constant.
- ii). Each blower shall be fitted with a variable speed motor and be capable of operating between 80 % and 110% of its nominal peak airflow demand.
- iii). The discharge pressure shall be calculated by the operator dependent on the final design layout of the aeration system and of the delivery manifold.
- iv). The blower shall be capable of supplying the design “mass flow” rate at maximum ambient inlet temperature of 50 deg C.
- v). Each of the blowers shall be capable of operating without surge in parallel with the other duty blower at the maximum mass flow against design maximum gauge pressure at the outlet pipe. The operator shall demonstrate this during testing and commissioning.
- vi). Performance curves for the blower system shall be submitted. Standard certified factory test sheets showing the results of each test shall be supplied to the Engineer prior to Delivery of the blowers. The blower unit shall be capable to operate at maximum duty for continuous operation.

1.3.8.1.2 Blower General Arrangement

The blower arrangement shall have the following features:

- i). The blowers shall be roots type units
- ii). Each blower shall be fitted with an acoustic enclosure
- iii). The arrangement shall be such that all blowers are accessible for operation and maintenance and the installation of additional blowers in the future is possible.
- iv). The inlet air to the blower house shall be filtered to suit the blowers and aeration diffusers selected.

1.3.8.1.3 Flexible Connections

- i). The blower discharge shall be fitted with an approved flexible sleeve with fixing clamps and a flanged outlet spigot for connection to site pipe work. If the blower inlet is via a common plenum the inlet pipe shall be also fitted with a flexible connection.
- ii). Flanges shall be drilled to Table D and shall comply with the required standard. Sleeves shall be manufactures from an approved non-metallic material suitable for the duty and location in which the blower are to be installed.

1.3.8.1.4 Pressure Relief Valve

- i). The pressure relief valve shall be sized and adjusted to allow the full flow of the blower to be discharged in the event of a blockage of valve closure in the downstream pipeline and without overloading the drive motor.
- ii). Each blower shall be fitted with a suitable pressure switch, which shall shut down the blower in the event of excessive discharge pressure. The pressure setting shall be lower than the set pressure of the pressure relief valves.
- iii). The pressure relief valve shall be installed at a height above 2m from floor and away from blower suction point. The pressure relief valve shall be fitted with a silencer.

1.3.8.1.5 Non-Return Valves

A non-return valve shall be installed on the discharge pipe work of each blower, upstream of the blower isolation valve.

1.1.1.1.1 Isolation Valves

Isolating valves shall be installed on the delivery pipe work of the blowers: such that each blower and all associated pipe work and valves upstream of the common distribution manifold can be dismantled without disruption to the normal operation of the plant.

1.3.8.1.6 Temperature Measurement

Temperature sensor complete with gauge of an approved type shall be supplied for each main distribution pipe work and for the blower room.

1.3.8.1.7 Piping Vibration

If the blower type selected produces a discharge flow with a pulsating characteristic, flow pulsation dampers shall be installed on the blower intake and discharge, as required, to eliminate excessive noise or vibration from this source.

1.3.8.2 Centrifugal type Turbo blowers

SPECIFICATIONS OF CENTRIFUGAL TURBO BLOWERS

A GENERAL

DESCRIPTION:

- A. This Section includes specifications of variable speed, air-foil bearing, direct drive centrifugal package blower unit(s) complete with all appurtenances as specified herein and in accordance with the Contract Documents. Bidder shall furnish complete package blower unit(s) and provide the services specified herein for placing the blower unit(s) into operation.
- B. Bidder shall be responsible for furnishing equipment, instrumentation, control system, materials, supplies, accessories, spare parts and services as specified herein for complete and operational blower unit(s). Bidder shall be responsible for providing consultation to the OWNER & TPI during installation, start-up, training and commissioning of the blower unit(s) as specified herein.
- C. Each unit shall include, but not limited to, the following components:
 - 1. Single stage Variable Speed Centrifugal Turbo blower
 - 2. High speed, direct drive, air or water cooled Permanent Magnet Synchronous Motor (PSMS) utilizing air-foil bearings, requiring no lubrication.

3. Forced air, or water cooled Integral Variable Frequency Drive (VFD) or Inverter
4. Base frame and fabricated acoustic enclosure supplied with noise attenuating media
5. Pneumatically operated Blow-off Valve and integral Blow-off Valve Silencer
6. Discharge check valve and discharge expansion joint
7. Inlet air filters
8. Local control panel (LCP)

D. Any exception to these specifications shall be specifically noted at time of bid.

REFERENCES

Where noted in the Specification materials, testing and installation shall be in accordance with the latest revisions of the following codes, standards and specifications.

1. American Society for Testing and Materials (ASTM)
2. American National Standards Institute (ANSI)
3. American Society of Mechanical Engineers (ASME)
4. PTC-10: 1997 Performance Test Code on Compressors and Exhausters (revised in 2003)
5. National Electric Code (NEC)
6. National Electric Manufacturers Association (NEMA)
7. Institute of Electrical and Electronic Engineers (IEEE)
8. 519: Harmonic Specifications
9. Conformité Européenne (CE)

SUBMITTALS

A. Bidder shall provide **the following with bid**:

1. Dimensional drawings of the specified blower unit(s). Dimensional drawing shall provide overall height and footprint dimensions of the blower unit(s). Dimensional drawings shall also include piping, electrical and instrumentation dimensions to all customer's connections.
2. Copy of SUPPLIER's ISO 9001 Certificate.
3. Installation list of blowers with equipment model and application type.
4. CE certification of the product

Failure of the SUPPLIER to provide the information listed above with its Bid may be ground for rejection of the Bid.

B. Bidder shall submit following documents **during execution of the project**:

All dimensions, calculations, and other information to be in SI units of measure.

1. Descriptive brochures and blower data sheets.
2. Predictive performance curves indicating speed, flow capacity and input power over the range of operation.
3. Outline installation drawing for each unit.
4. Dimensional drawings of the blower unit. Dimensional drawings shall include piping, electrical and instrumentation dimensions to all customer connection. Dimensional drawing necessary to coordinate piping layout with structural, architectural, electrical and other required mechanical work.
5. Anchor bolt layout drawings, if applicable.
6. Instrumentation and control system schematics, tubing and conduit details, and wiring diagrams for furnished electrical and control components.
7. Drawings of the local factory control panel (LCP).
8. Blower package weight

C. Installation, Operations and Maintenance (IO&M) Manual to be submitted **during project execution**:

All dimensions, calculations and other information to be in (System International) SI units of measure.

1. A list of components fully describing the following items:
 - a. Mechanical and structural components
 - b. Instruments
 - c. Local Control Panel (LCP)
 - d. Operator Interface / Machine monitors
 - e. Electrical Components
2. Dimensional drawings showing the general arrangement, enclosure dimensions, overall weights, weights and overall dimensions of major package components requiring removal for maintenance, and clearances required around the package for maintenance access.
3. Drawing of control panels to include:
 - a. Electrical diagram
 - b. Interconnection details to all components outside the panel
 - c. Door electrical layout
 - d. Interior electrical layout
4. Input/ output (I/O) listing for LCP.

5. Indicate all scheduled maintenance requirements and routine inspections. Include maintenance summary forms.
6. Common/ frequent error troubleshooting guide.
7. Local sales representative's contact information with the company name, contact person, phone numbers, e-mail address, and physical address.

D. Factory test reports during execution of project:

All dimensions, calculations and other information to be in SI units of measure.

1. Factory Certified Report of dynamic balancing of the rotor assembly.
2. Factory Performance Test Report: SUPPLIER shall supply a report.

DESIGN CONDITIONS & POWER GUARANTEE

- A. Bidder shall design blower equipment to the following site conditions and demands. Following conditions represent the **TOTAL** demand at the OWNER's facility with regards to this bid. Bidder shall supply equipment sufficient to handle conditions listed in **Table 1: Design Conditions**. Required spare blower equipment and appurtenances shall be listed separately.

Table 1: Design Conditions						
Design Point	Flow (N-m3/hr)	Barometric Pressure (kPaA)	Package Inlet Pressure (kPaA)	Package Inlet Temperature (°C)	Discharge Pressure (kPaA)	Relative Humidity (%)
1						
2						
3						
4						
5						

Flow reference point is to N-m3/hr conditions, where air is defined as 101.325 kPa (abs.) / 0°C / 0% RH.

- B. Blower shall be capable of continuous duty and operation as per Indian weather conditions for the following.

Range of Ambient Temperature (°C)

Range of Relative Humidity (%)

Minimum Turndown at Rated Flow and Constant Design Pressure (%)

- C. Blower shall be capable of operating continuously and satisfactory at all design points listed in **Table 1: Design Conditions**, without surge, vibration, hunting, or excessive heating of the blower equipment.
- D. Parallel operation with multiple blowers including: rotary positive displacement, horizontally split multistage compressors, vertically split multistage compressors, integrally geared compressors, integral motor turbo compressors and single stage centrifugal compressors shall be acceptable without special start-up and shut-down procedures or reservoir tank at the discharge pipe. Blowers without the parallel operation capability shall not be acceptable.

FACTORY PERFORMANCE TESTING

A. Performance Testing

1. Upon completion of assembly, the blower package unit(s) shall be performance tested. If required by the OWNER, the test shall be witnessed by a representative of the OWNER i.e. (TPI) at the expense of the OWNER or Bidder. The witnessing party shall sign, stamp and date the test procedure and results, certifying that the assembled systems were tested together, as a system, in the SUPPLIER's facility.
2. Performance test should be in accordance to ASME PTC-10
Functional testing of entire package, instrumentation, ancillary components, and LCP shall also be performed.
3. Provide minimum fifteen (15) days' notice to OWNER prior to start of Factory Performance Testing.
4. All test equipment shall be calibrated and certified by an independent test agency or TPI of Agency no more than twelve (12) months prior to the test date.
5. A calibrated power meter, or watt meter, shall be instantaneously monitoring all electrical legs for voltage and amperage to calculate instantaneous power usage. Power meter shall measure all electrical power input to the system as described, including all auxiliary systems. Measured power shall include wire-to-air and include all losses associated with electrical power, including, but not limited to the motor, inverter, and cooling system.
6. The measurement of power consumption with the power meter shall be measured with all of the components inside the enclosure and all doors closed as the normal operation condition.
7. Test Report shall present computations in accordance with the appropriate section or testing codes with performance curves showing flow, pressure and power inputs.
8. Test Report shall be submitted for approval prior to equipment shipment.

B. The following practice shall be performed to ensure and verify performance guarantees.

1. System Description: For the purposes of determining overall power consumption (power to package) the system shall consist of a blower, motor, variable speed drive, filters, and water/air cooling system to cool motor and the inverter including external piping, wiring, instrumentation and appurtenances up the point of connection to the OWNER's equipment.
2. Design Conditions
 - a) Inlet conditions are defined as the conditions that exist at the inlet of the package. Discharge conditions are defined as the conditions that exist at the discharge flange of the package.
 - i. Jobsite Elevation: 126.00m.MSL
 - ii. Specified Flow and Pressure: See **Table 1: Design Conditions**
 - iii. Standard Inlet Conditions:
 - a. Pressure: 101.325kPaA
 - b. Temperature: 0° C
 - c. Relative Humidity: 0 %
 - iv. During normal operations at or between any of the combinations of the above stated conditions, the electrical power draw of the package shall not exceed electrical capacity at site and the blowers shall not surge.
3. Blower unit(s) shall be capable of operating continuously at any point between the minimum and the maximum flows without surge, vibration, idling or excessive heating.
4. Test Report shall include a certified factory test performance curve showing flow and pressure at 100%, 90%, 80% and 70% of full speed. Factory test curve shall also include curves for package demand power.

WARRANTY

SUPPLIER shall guarantee in writing the unit(s) to be free of defects in material and workmanship for a period of twelve (12) months from the date of initial operation under the operating conditions specified or eighteen (18) months after receipt of blower equipment, whichever occurs first.

DELIVERY, STORAGE AND HANDLING

- A. Blower equipment shall be provided with all enclosure openings sealed and internal machined surfaces protected.
- B. Inlet filters, expansion joint and transition piping shall be cleaned, sealed and skid-mounted for shipment (to the extent practical), and be adequately protected to avoid damages.
- C. All blower equipment and appurtenances shall be skid mounted and protected against damage during shipment. All parts shall be properly protected so that no damage or deterioration will occur until installation is complete and the unit(s) and equipment are ready for operation.
- D. Unloading of the equipment shall be performed by the Bidder. All boxes, crates and packages shall be inspected by the OWNER's TPI and Bidder upon delivery to the site. TPI shall notify the Bidder in writing if any loss or damage exists to blower equipment or appurtenances.
- E. Equipment shall be stored by the Bidder in accordance with SUPPLIER's instructions.

INSTALLATION

- A. Each blower package shall be mounted on a flat and level surface in accordance with the recommendations of the SUPPLIER, as outlined in the SUPPLIER's IO & M Manual.
- B. Commissioning and Start-Up shall be executed in conjunction with OWNER's representatives to coordinate system tuning activities to ensure the OWNER's aeration system works in harmony with equipment supplied by the blower equipment SUPPLIER.

SUPPLIER'S FIELD SERVICES

- A. Bidder shall furnish a Start-Up service representative to inspect the final installation and supervise commissioning of blower equipment and appurtenances. Services of the representative shall be provided for a maximum of two (2), eight (8) hour days for the entire aeration blower system.
-
- 1. Bidder shall provide the following services: Written documentation for equipment check out including who performed the check, when the check was performed, what was the final setting for tolerance (if applicable) and who witnessed the final setting.
 - a. Verify proper connection of piping and installation of accessories and appurtenances.

- b. Verify levelling and blower enclosure.
 - c. Verify proper wiring and all instrumentation of field wired items.
2. Bidder shall provide a four (4) hour field acceptance test for each blower. Field acceptance test shall demonstrate that under conditions of operation each unit:
- a) Has not been damaged under transportation or installation
 - b) Has been properly installed
 - c) Has fully functional instrumentation that is properly calibrated and set.
 - d) Will start, run, and stop in the prescribed manner
 - e) Will run through the entire range of operation for specified pressure and flow.
 - f) Has proper shutdown sequence of standard stop, soft stop, and emergency stop.
 - g) Is free of overheating any parts
 - h) Is free of objectionable vibration and noise
 - i) Is free of overloading of any part
- B. Bidder shall furnish one training session upon commissioning of the blower equipment. Training will be held at the OWNER's location. The Bidder's representative will have complete knowledge of proper blower operation and of the blower software programs supplied in this section. Training session shall be for one (1), eight (8) hour day.
- C. Should difficulties in commissioning arise because of Bidder's equipment fabrications or programming the Bidder shall supply a representative until the commissioning issues are resolved and the equipment is properly functioning.

QUALITY ASSURANCE

- A. The blower package systems, including blowers, motors, controls and all appurtenances to form an integral system, shall be supplied by one manufacturer who shall provide all the equipment and appurtenances regardless of manufacturer.
- B. All blower equipment and appurtenances shall be provided as a complete and integrated design to insure proper coordination, compatibility and operation of the system.
- C. Blower equipment shall be performance tested as specified.
- D. The entire blower system and control panel shall be tested as an operational system before shipment. All start/ stop and running sequences and all safety alarms shall be tested. The Bidder's and/or CONSULTANT's or OWNER's witnessing engineer shall

sign the test procedures and results, certifying that the assembled blower equipment and control panel were tested together, as a system, in the SUPPLIER's facility. SUPPLIER will provide two (2) weeks' notice, in writing, for the witnessing of the testing.

SPARE PARTS

- A. Bidder shall furnish all special tools and appliances necessary to disassemble, service, repair and adjust the blower equipment and appurtenances, excluding the blower core (blower and motor) or other major components as identified by the SUPPLIER.
- B. Bidder shall furnish the following spare parts as listed below, provided these components are included in the package blower unit:
 - 1. Two (2) spare air filters of each size utilized on the blower for each blower package. Spares shall include spare air filters for spare blower unit(s), if applicable.
 - 2. Cooling system pump, if applicable.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Approved Blower Manufacturer: No substitutes or bids will be accepted unless pre-approved and written in this Specification.
- B. It shall be the responsibility of the Bidder to perform any required design and coordination associated with, but not limited to, mechanical equipment layout, electrical wiring, conduit and controls, and structural/ architectural work, at no additional cost to the OWNER. The proposed redesign shall be subject to review and approval of the CONSULTANT.
- C. Manufacturer Qualifications.
 - 1. List of successful installations certified by client & institution shall be provided.
 - 2. Established in the market with proven results for a minimum of Seven (7)years
 - 3. Should be a ISO 9000 certified manufacturing facility
 - 4. Should have testing facilities for complete assembled unit in the manufacturing facility.

SYSTEM DESCRIPTION:

- A. Bidder shall supply ____ (X) unit(s) capable of meeting the specified total system capacity with all blowers operating.
- B. Bidder shall supply ____ (X) spare unit(s) that are to be duplicates of the unit(s) provided. These unit(s) shall be capable of meeting the specified system capacity stated herein.

GENERAL

- A. Bidder shall supply, coordinate and calibrate all items specified.
- B. Unit(s) shall be capable of attenuating noise levels emitted from the package to eightyfive (85) dBA at one (1) meter distance from the package free field. Noise attenuation of the discharge piping, silencers and inlet piping (if applicable) shall be the responsibility of the OWNER.
- C. All components shall be constructed using UL, ULC or CE listed components to the extent practical, or deemed appropriate by OWNER or CONSULTANT.

2.04 MATERIALS AND CONSTRUCTION

- A. Blower package(s) shall be of the direct drive, permanent magnet synchronous motor (PMSM) with commercially available variable frequency drive (VFD) with local service capability. Blower package(s) of the induction synchronous motor or brushless direct current type shall not be acceptable.
- B. The integral blower motor shaft shall be titanium alloy and suitably ground. The impeller shall be mounted directly to the motor shaft and shall be dynamically balanced.
- C. Blower casing/ volute shall be Aluminum Alloy 356 and have a maximum continuous duty design pressure rating of 200kPaG at design conditions.
- D. Blower impeller(s) shall be 5-axis machined from Aluminum Alloy AL 7075. The lateral critical speed shall be at least one hundred and twenty (120) percent of the maximum allowable operating speed. Casted impeller of any material shall not be acceptable.
- E. Permanent magnet material for motor construction shall be Samarium-Cobalt Alloy. With the rotor being of a titanium alloy.
- F. Radial and axial bearings shall be of the bump-style, and air-foil type. Bearing design shall incorporate a high-strength metallic spring substrate with a low friction coating to protect against start-up and shutdown contact with the shaft. Bearing shall be

constructed from Inconel AlloyX-750, suitable for high temperature and abrasion resistance. Bearing shall not require any lubricant and shall be oil-free. Roller element and magnetic bearings shall not be allowed.

- G. The shaft seal shall be of the non-contact type, and operated dry. Any leakage shall be minimized by having small clearances between the male and female components. The female component shall be made of aluminum to avoid damage to the shaft in the event of a seal rub.

2.05 ENCLOSURE

- A. Each blower enclosure shall be CE certified. Evidence of CE certification for the blower package(s) shall be provided with the shop drawings at time of Shop Drawing submittal.
- B. Enclosure shall be capable of attenuating noise levels emitted from the package to eighty five(85) dBA at one (1) meter distance from the package \pm three (3) dBA, free field. Noise attenuation of the discharge piping, silencers and inlet piping (if applicable) shall be the responsibility of the OWNER.
- C. Blower shall be mounted on a sturdy steal base frame with forklift slots on each of the four (4) sides and four (4) suitably sized eye bolts welded to the enclosure allowing the unit to be placed on any level floor capable of taking the weight of the unit, no foundation or fixation should be required.
- D. Enclosure shall be designed for ease of inspection and maintenance of all blower system components. Hinged or removable panels shall provide access to the blower and the auxiliary systems. Doors shall have a welded, reinforced perimeter frame and a welded support structure to prevent sagging or misalignment.
- E. Enclosure shall be protected against corrosion, fungus and insects.
- F. Enclosure shall have a filter mounting frame allowing external removal and replacement of all filters on the enclosure.
- G. All electrical components shall be CE certified with listing label shown on the nameplate and installed at the point of manufacture.
- H. Enclosures shall be prepared and powder coated on all interior and exterior surfaces with the manufacturers standard powder coating and standard color.
- I. Enclosure shall have a nameplate which shall provide the following: design of blower (specification), working fluid, bearing type, electrical requirements, discharge pipe connection, motor power and design speed, motor insulation class, blower package weight, manufacturers model number and manufacturers serial number.
- J. All components shall be constructed using UL, ULC or CE listed components to the extent practical, or deemed appropriate by OWNER or CONSULTANT.

MATERIALS AND CONSTRUCTION

- A. Blower package(s) shall be of the direct drive, permanent magnet synchronous motor (PMSM) with commercially available variable frequency drive (VFD) with local service capability. Blower package(s) of the induction synchronous motor or brushless direct current type shall not be acceptable.
- B. The integral blower motor shaft shall be titanium alloy and suitably ground. The impeller shall be mounted directly to the motor shaft and shall be dynamically balanced.
- C. Blower casing/ volute shall be Aluminum Alloy 356 and have a maximum continuous duty design pressure rating of 200kPaG at design conditions.
- D. Blower impeller(s) shall be 5-axis machined from Aluminum Alloy AL 7075. The lateral critical speed shall be at least one hundred and twenty (120) percent of the maximum allowable operating speed. Casted impeller of any material shall not be acceptable.
- E. Permanent magnet material for motor construction shall be Samarium-Cobalt Alloy. With the rotor being of a titanium alloy.
- F. Radial and axial bearings shall be of the bump-style, and air-foil type. Bearing design shall incorporate a high-strength metallic spring substrate with a low friction coating to protect against start-up and shutdown contact with the shaft. Bearing shall be constructed from Inconel AlloyX-750, suitable for high temperature and abrasion resistance. Bearing shall not require any lubricant and shall be oil-free. Roller element and magnetic bearings shall not be allowed.
- G. The shaft seal shall be of the non-contact type, and operated dry. Any leakage shall be minimized by having small clearances between the male and female components. The female component shall be made of aluminum to avoid damage to the shaft in the event of a seal rub.

ENCLOSURE

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- B. Enclosure shall be capable of attenuating noise levels emitted from the package to eighty five(85) dBA at one (1) meter distance from the package \pm three (3) dBA, free field. Noise attenuation of the discharge piping, silencers and inlet piping (if applicable) shall be the responsibility of the OWNER.
- C. Blower shall be mounted on a sturdy steal base frame with forklift slots on each of the four (4) sides and four (4) suitably sized eye bolts welded to the enclosure

allowing the unit to be placed on any level floor capable of taking the weight of the unit, no foundation or fixation should be required.

- D. Enclosure shall be designed for ease of inspection and maintenance of all blower system components. Hinged or removable panels shall provide access to the blower and the auxiliary systems. Doors shall have a welded, reinforced perimeter frame and a welded support structure to prevent sagging or misalignment.
- E. Enclosure shall be protected against corrosion, fungus and insects.
- F. Enclosure shall have a filter mounting frame allowing external removal and replacement of all filters on the enclosure.
- G. All electrical components shall be CE certified with listing label shown on the nameplate and installed at the point of manufacture.
- H. Enclosures shall be prepared and powder coated on all interior and exterior surfaces with the manufacturers standard powder coating and standard color.
- I. Enclosure shall have a nameplate which shall provide the following: design of blower (specification), working fluid, bearing type, electrical requirements, discharge pipe connection, motor power and design speed, motor insulation class, blower package weight, manufacturers model number and manufacturers serial number.

1.3.8.3 Air Compressors

However, if a compressor system is required for some reason, it shall comprise compressors, after-coolers and air dryers, duty/standby air receivers together with control equipments, oil eliminating filters, flow regulators and oil mist lubricator as required.

Electrically driven air compressor sets shall operate up to minimum 10 bar working pressure.

Compressor sets with at least 1 standby shall be provided complete with the following:

- i). Common base frame for compressor & Motor
- ii). Single stage air cooler unit
- iii). Isolating valves
- iv). Air filter and silencer
- v). Pressure relief valve of excess pressure safety device
- vi). Pressure reducing valves
- vii). Pressure gauges
- viii). Off loading Piston
- ix). Automatic changeover (failure of duty unit)
- x). Drain pipes
- xi). V-Belt drive arrangement with belt Guard
- xii). Stoppers
- xiii). Air receivers

xiv). Other necessary appurtenances

Compressors shall be arranged for automatic changeover on failure of the duty unit. Failure of the duty unit shall initiate an alarm. Control equipment shall include automatic unloading valves, pressure switches for duty standby and alarm, and lockable changeover switches.

One duty & One standby after cooler shall be provided. Water cooler of air blast types will be considered. Air receivers shall be design and fabricated in accordance with relevant approved standards. They shall be mounted vertically on steel feet so that sufficient space is allowed for each access to the whole outside surface. Receivers shall be provided with drain cocks piped to drain pressure gauges, relief & check valves.

Supply of all necessary electrical components, devices, equipment, control panels, etc. Together with cabling, earthing provisions, etc. Shall be the responsibility of the operator.

Interconnecting pipe work shall be arranged with drain cocks piped to waste.

1.3.8.4 Aeration Diffusers

- i). Air diffuser system consist of tube type porous membrane of Acid resistant silicon based rubber with diameter not exceeding 65 mm size, single piece injection moulded PP support tube, SS clams.
- ii). Entire diffuser has to be manufactured, assembled, tested in factory premises & no site work is permitted.
- iii). Flat surface facing upwards as membrane shall not be accepted.
- iv). The aeration tank is used to remove oxygen consuming organic matter from the effluent by biological treatment. Diffused aeration is used for air supply. The bubbles produced from the diffuser are of extremely small size between 0.5-0.8 mm, thus the total surface area that interacts is large and the contact time of bubble is large due to slow rise of bubbles. The system is thus extremely power efficient in terms of oxygen transfer efficiency. The flow of fine bubble of 0.8 mm in size provides a gentle mixing, which prevents flock shear.
- v). Fine Bubble diffuser consists of a porous membrane made of acid resistant silicon based rubber. Each diffuser is fully supported over the length and circumference on the single piece injection molded polypropylene (PP) tube with a RIDGE on the top to hold the membrane in position against the velocity generated in the wastewater.
- vi). No drilled holes on the supports tubes are permitted and only channel type of arrangement for entry of air into membrane is desired. Air opening on the membrane should be 0.8-1 mm with staggered perforation.
- vii). The diffuser will be retained in place by two clamps. It is fitted to the pipe lateral by CLIPIN arrangement. The Laterals are connected to a pipe header. The wetted parts of the system shall be made of Non-corrosive material specifically SS 316. During power shutdown at the STP the membrane will contract and lose around the PP support pipe and means shall be provided to prevent any back flow.

- viii). Each diffuser shall consist of the following: Minimum 65 m OD PP injection moulded support pipe.
 - a. Porous membrane made of silicon based rubber lateral.
 - b. RCC support block with SS 316 clamping.
 - c. Flexible hose pipe (Drop pipe for each diffuser assembly)
 - d. PP ropes for lifting and guide position.
 - e. Hose clamp
 - f. pipe connector
 - g. GI barrel nipple with connector for connection with pipe
- ix). Complete diffuser shall be assembled at original factory level and site fabrication of diffuser is not acceptable.
- x). All hardware accessories including clamps, fasteners, fan-hooks, eye bolts, should be of SS 316 material only.

1.3.8.5 Air supply Pipe Work

General design Criteria

Many factors need to be incorporated in the design of the air distribution pipe work to minimize the potential of noise problems occurring. Factors to be considered in the design of the air pipe work to be minimize noise level shall includes:

- i). The diameter of the pipe work, to keep velocity low.
- ii). The connection of the blower discharge pipes to the manifold should be “wye”, not at right angles.
- iii). No blind flange at the end of the manifold.
- iv). The manifold shall be design to ensure air travels in one direction.
- v). The air pipe work shall be designed to minimize changes of direction and use large radius bends.
- vi). Flexible connections shall be provided between the diffuser assembly nits and the main air supply pipe work to allow for any differential movements.
- vii). Expansion and contraction shall be fully allowed for in the design and installation of the air distribution pipe work.
- viii). Rain taps shall be provided on the air pipe work to allow draining of moisture.
- ix). The pipe work and the support brackets shall be galvanized steel.
- x). Pipe work shall have inbuilt flexibility such as packer flanges for reasonable construction tolerances on the structures to which it is attached.

Pipe shall be designed to ensure the efficient operation of the aeration system and compliance with the noise limitations. All valves in the air delivery system shall be correctly selected for the duty. Calculations of Cv (Head loss co-efficient) values for the range of flows

and pressure losses across each valve should be prepared to ensure that each valve has adequate range of controllability for the duty.

However the air piping submerged in sewage has to be in SS316 confirming to IS specification. Two spare drop pipes with diffuser elements shall be supplied by the Operator one for each compartment. This will be used to replace the choked diffusers drop pipe or on preventive basis on rotation. The choked one will be attended to and used as spare drop pipe.

1.3.8.5.1 Air supply Headers

The air supply headers run from the main air distribution pipe work to the down comers. Pipe work shall have inbuilt flexibility such as packer flanges for future modifications and to allow for reasonable construction tolerances on the structures to which it is attached. An isolation valve for each main air supply pipe shall be installed at the point of connection to the main distribution pipe work. The design of the main air supply header shall incorporate all components necessary to enable the easy connection of the main distribution pipe work to the main air supply header.

1.3.8.5.2 Blower Discharge Pipe Work

The Discharge pipe work from each blower shall be connected to a common manifold. Flexible connections shall be provided between the blower assembly units and the discharge pipe work to allow for any differential movements. The design of the manifold pipe work shall incorporate all components necessary to enable the easy connection to the main distribution pipe work.

1.3.8.5.3 Air Flow Measurement

The amount of air being supplied to each air supply header shall be measured by the installation of flow measuring devices. The flow measuring devices shall be suitable for the intended application. The sensor assembly shall be supplied with suitable fittings which shall enable easy removal during maintenance. The accuracy of the flow meter shall be within 5% of the minimum design flow rate. The installation shall provide adequate length of straight pipe upstream and downstream of the flow meter to ensure the accuracy of the meter is attained.

Pressure and temperature sensors, shall be provided to measure the pressure and temperature of the air in the pipe, upstream of the flow measurement device.

Pressure and temperature compensation measurements shall be provided for volumetric correction if the control air is based on airflow rate.

1.3.8.5.4 Pressure Gauges

Pressure gauges of an approved type shall be installed on each main distribution pipe work and main header.

1.3.8.5.5 Leak & Pattern testing Diffuser System

The diffuser system shall be visually tested by filling the tanks with clean water to level 1 m above the top of the diffuser assembly units. Air shall then be passed through the diffusers and a visual assessment of the diffuse operation shall be made.

The visual assessment shall include the following minimum inspection:

- i). Checking all diffusers for installation level within the required tolerances.
- ii). Checking that all joints along the diffuser headers have been made airtight
- iii). Checking the required air distribution of diffused air is achieved across the entire tank floor.

1.3.9 Aspirating Aerator

1.3.9.1 General

The Supplied equipment must be in operating condition in India for minimum of three years in any Government plant with minimum three successful installations and documentary proof of performance certificates of the same shall be produced to approving authority. The client reserves the right to inspect any one of the successful installation at the referred site; in case found not satisfactory, vendor shall be disqualified.

1.3.9.2 General Description

Aspirator aeration shall consist of motor driven aspirator Draft tube/Air Suction Inlet/blower. The Device shall draw air through a hollow tube and inject it underwater where both high velocity and propeller action create turbulence and diffuse the air bubbles.

The assembly shall consist of electric motor connected to a hollow shaft with a protective housing positioned at a suitable angle downward into the water. The hollow shaft shall drive a mixing propeller and diffuser beneath the water surface to effect fine bubble diffused aeration.

1.3.9.2.1 AERATOR/MIXER COMPONENTS:

A. AERATOR DRIVE MOTOR

- 1) Motor shall be suitable to operate at 3phase, 415 volts, 50Hz supply. Motor shall conform to IS325.
- 2) Motor shall be provided with suitable starter and starter panel as per tender specifications.
- 3) Motor enclosure configuration shall be totally enclosed, fan cooled TEFC and meet IP65 specifications.
- 4) Motor shall be suitable for S1 duty, shall have class F insulation and temperature rise to class B.
- 5) Motor shall be of energy efficiency class EFF-1 as per IS-12615.
- 6) Winding, bearing, temperature detector shall be provided for motors above 200kW. Space heater shall be provided for motor above 30kW.
- 7) Motor frame shall be made-up of cast iron end brackets and cast iron body. Fan material shall be 74urbulenc or propylene with metal hub. Fan cover shall be carbon steel.
- 8) Total motor shall be epoxy painted – Final Total Dry film thickness of minimum 180 microns.
- 9) The noise level of the motor shall be within acceptable limit (<85dB) in accordance with IEC specifications.

B. BLOWER/DRAFT TUBE/AIR SUCTION INLET

- 1) The equipment shall include a high efficiency regenerative blower/Draft Tube/Air Suction Inlet sized to provide sufficient airflow to yield the rated oxygen transfer capacity. Such Device shall include the following features:
- 2) Maintenance free and CE compliant - Declaration of Conformity on file
- 3) Aluminum alloy construction
- 4) Inlet and outlet sound attenuating silencers/acoustic hood to minimize noise, if applicable.
- 5) Inlet filters with epoxy-coated wire mesh media rated for 150 microns or better, if applicable.
- 6) The blowers shall be tropicalized for corrosion resistance and motors should be suitable for 415V, 50Hz cycle, 3 phase service and with IP65 rating.

C. BEARING

- 1) The aerator shall be supplied with a field replaceable water lubricated lower support bearing /Grease Lubricated Bearing. The bearing shall be constructed of an appropriate material for the application inside a fiber backing. The bearing shall be press-fitted into the housing to allow ease of replacement.

D. SLEEVE :

- 1) The sleeve shall be solid, homogeneous and replaceable hardened non-metallic sleeve.

E. PROPELLERS:

- 1) The stainless steel mixing propeller shall be specifically designed to maximize oxygen transfer and mixing characteristics. Propellers shall be self-tightening such that the propeller threads tighten on the shaft threads during normal operation. The entire flow of air shall pass through the propeller via the hollow drive shaft along the axis of the propeller hub.
- 2) The propeller design shall be tested in clean water and shown to draw a minimum of 85% of the recommended full motor amperage load at nameplate voltage and power factor. The propeller shall be designed to allow easy removal and replacement in the field.

F. FLOTATION:

- 1) The aerator flotation assembly shall consist of suitable number of pontoons/Suitable Floating arrangement. Galvanized or stainless steel structural members to be used to prevent corrosion. To allow for servicing by not removing the aerator from the flotation, the flotation assembly shall be designed so the aerator may be rotated completely out of the water and taking care of water level fluctuations.

Note- The Floating Arrangement may not be applicable in Fixed type Installation for Aerator.

G. BRIDGEMOUNT:

- 1) The fixed bridge mount shall be made of Galvanized steel. The recommendation of the Float and Fixed mount shall be as per recommendation of the client according to the site conditions.

H. ELECTRICAL SERVICE CABLE:

Cable shall be IEC/IS/CSA/UL approved for severe environments, suitable for underwater service and one continuous length based on the site condition. The cable shall be jacketed, flexible stranded cable with individually wrapped conductors.

1.1.1.1.2 Approved Makes: Aire-O2, Hitachi, ITT or any other make approved by SMC.

1.3.9.3 Particular Specification :-

1. Contractor shall explain the technology by suitable simulation software to explain the bubble formation and zone of aeration to ensure total aeration basin shall get uniform oxygen zone is created.
2. Float and Fixed mount both are acceptable and shall be provided with 100% installed/

shelf standby for the total system.

3. Stad Pro model along with structural calculation shall be provided for Float or/and Fixed mounting.
4. The bidder shall provide support documents/certificates to testify the claimed oxygen transfer efficiency achieved by the aerator for minimum 5m depth in line with tender specifications, for example- inspection report by competent third party or/and certified lab reports.

1.3.10 CLARIFLOCCULATION WORKS

i). **WORKS TO BE INCLUDED:**

The works which are to be included by the contractor this section of the treatment process shall comprise at least the following:

- a) The design and necessary arrangement for the “Clarriflocculator” to flocculate settle and decant the coagulated water from the inlet works.
- b) The design and necessary arrangement for the control removal by gravity of the settled sludge from the Clarriflocculator and the waste product
- c) The design and necessary arrangement to drain down the clarifiers and provide a facility to scour the sludge withdrawal, under higher head.
- d) The design and necessary arrangement for the uniform collection of settled water from the Clarriflocculator and its delivery to the filter battery for filtration.
- e) The supply and installation of Clarriflocculator.

ii). **BRIEF DESCRIPTION OF THE WORKS:**

The Clarriflocculator shall be designed entirely in reinforced concrete. The tank shall be arranged to suit the works flow path, convenience of operation and effective maintenance of structure and equipment. The task shall be disposed minimise hydraulic losses and to achieve optimization of performance. Separate zones for flocculation and sedimentation shall be provided.

iii). **GENERAL DESIGN CRITERIA AND PERFORMANCE GUARANTEE:**

The clarification works shall be designed to:-

- a) Continually clarify the water for filtration and meet the performance standards with a unit flow rate of design flow as per data sheet during monsoon period and during commissioning period fair weather trials, clarify higher rates of flow.
- b) Efficient removal of waste products from the process with minimum water loss.

c) The contractor shall guarantee that following chemical coagulation for the monsoon quality raw water, the water leaving the sedimentation tank shall comply with the following on 95% of occasions.

- Turbidity: Not greater than 10 NTU
- Suspended solids: Not greater than 10 Mg/l. Solids.
- Total Aluminium: Not greater than 0.5 mg/l on the laboratory treatment tests.

The test results indicating non-achievement of water quality shall make modifications in mechanical or electrical or chemical works in order to achieve the specified quality to the entire satisfaction of the Engineer.

iv). CLARIFLOCCULATION PROCESS:

The clarification process designed, offered and supplied by the contractor shall achieve flocculation, sedimentation and decantation in the self-contained circular tank. The process shall not include a sludge blanket, solids recirculation facility or any other process to enhance the performance of the self contained unit.

The Clarriflocculator shall be provided with the following:

- An inlet feed pipe to the clarifier centre.
- A central, mechanically agitated flocculation zone.
- Around the flocculator an upward flow annular sedimentation zone where in the sludge shall get settled to the floor of the annular zone floor for scraped clearance.
- Decantation of settled water uniformly from the surface of the sedimentation zone by launders to the filter battery.

v). PERMITTED VARIATION IN THE C LARIFLOCCULATION STAGE :

Tendering contractors are informed that the clarification arrangement specified herein has been well proven in India. And many similar clarification works are operating successfully and maintained satisfactorily even in rural areas.

The tendering contractors may offer their own design of the clarifier type outlined in this section meeting the general requirements and specifications given for the works, its commencements, performance and standards, wherever possible.

vi). ALTERNATIVE C LARIFLOCCULATION PROCESSES:

If the contractor wishes he may submit an additional offer, his own alternative design for the clarification works, if necessary, the contractor shall also include full details of his amended design of the inlet works to 77urbul the requirements of his alternative design for the same.

vii). CLARIFLOCCULATOR DESIGN:

The Clariflocculator shall be design to the following criteria:

Flocculation zone	30 minutes detention period at a flow rate of design flow as per data sheet
Depth of tank	3.5 m
Velocity of floc	0.2 to 0.4 m./sec
Flocculation	Flocculator supplied with paddle
Agitation	Agitators of substantial construction and designed to achieve an internal maximum "G" = 10 to 75 Sec. -1
Flocculator	Total area of paddles shall be 10 to 25% of cross sectional area of tank. Design of paddle shall be given as per the latest CPHEEO volume. To be adjusted suitably as per scope of work and design
Zone separation	Distinct isolation by a circular concrete wall of the flocculation and sedimentation zones.
Outlet velocity of settling tank	0.15 to 0.25 m/sec
Sedimentation	The ports for the entry of flocculated water shall be sized and arranged to give steady and uniformly distributed flows in the sedimentation zone, to avoid the break down of flocs
Surface loading	Shall not be more than 30 m ³ /m ² /day based on the net open surface area of sedimentation zone. The area occupied by decanting weirs shall not be included in the net effective open surface area
Detention period- Sedimentation Zone	2 hours & 30 minutes
Zone dimensions	Floor slope not greater than 1:10 for scrapped sludge transit to centre
Decanting weirs loading	Maximum loading of 300 m ³ /m/day
Sludge collection	By single arm scraper hung from an overhead rotating bridge and driven by an outer perimeter motor driven steel wheel traction unit on a peripheral circular steel rail (Rubber typed machine are not preferred).
Sludge withdrawal	By telescopic draw of valve. The sludge draw off pipes shall be at least 250 mm. Diameter

25% extra above the designed depth for sludge collection

viii). FLOCCULATION ZONE

Flocculation zone shall be circular in plan, with a volumetric capacity of 30 minutes detention and be substantially separate from the sedimentation zone.

The zone separation wall shall be in reinforced concrete, supported from the tank base in columns or a supporting wall

ix). ZONE ENTRY

The flows in the flocculation zone shall be dispersed and there shall not be any short circulating in the retention to ensure an even distribution of flows. The inlet pipe will feed the central vertical reinforced concrete diffuser column outlet ports

x). SCRAPED SLUDGE REMOVAL:

Adequate means of continuous sludge removal from flocculator floor is envisaged.

Double arm type center torque driven machines are illustrated in the conceptual arrangement shown on the drawings.

xi). AGITATION:

A continual treatment process agitation shall be provided in the flocculation zone to ensure satisfactory floc formation and preservation for subsequent sedimentation.

The Gt values shall be in a suitable (104 to 105) to suit the raw water characteristics, 79turbulence flow rates at all times.

The design shall achieve the agitation by internal hydraulic sheet induced either between rotors and stators or between opposing rotational elements. If individual paddle assemblies are provided, they shall be static mounted from a concrete platform and there shall be at least four such units in each flocculator. If individual rotating paddles mounted from a bridge are offered, they shall be of a very study design.

The contractor shall include full details of his proposed flocculation machinery with his tender along with detailed drawings, energy calculations, also the range of rotational and tip speeds proposed.

The peripheral speed of paddle shall be between 0.3 to 0.40 m/sec.

xii). SLUDGE REMOVAL:

In consideration to the design and raw water conditions, the arrangements for continual removal of settled solids from the flocculator base may be provided, if necessary.

xiii). SEDIMENTATION ZONE ENTRY:

The sedimentation zone entry arrangements shall be specifically designed to preserve the size and settling characteristics of previously formed flocs. Entry ports shall not create turbulence and keep the entering water free from hydraulic currents induced by the flocculating machinery. Flows through the entry ports shall be radial and well distributed in the entire sedimentation zone. Hydraulic flows in the sedimentation zone shall be at low level with velocities between 0.15 to 0.25 m/sec. Contractor shall specifically state these requirements with their calculations in their submissions.

xiv). SEDIMENTATION ZONE:

Sedimentation zone shall be circular in plan with upward flow arrangements and have a total net surface area in order to limit the design surface loading to 30 m³/m²/day. The settling sludge shall fall to the floor for scraped collection and clarified settled water decanted into collecting launders.

xv). FLOOR SLOPE:

The sedimentation zone floor shall radially fall to the center at a slope not more than 1:10.

xvi). SIDE WALL DEPTH:

The minimum outer side wall depth shall not be less than 3.5 m. From working top water level to the point of intersection of vertical internal surface of the outer tank wall with that of the finished tank floor.

xvii). LAUNDERS:

Launders shall be constructed in reinforced concrete, either attached to the perimeter wall or suspended within tank. The Launder arrangement shall minimise the rising flock for uniform decantation of settle water. The launder channel shall be provided either with square openings of size with a maximum weir loading of 300 m³/day/m length of weir in the form of notches provided in steel plate of minimum thickness of 10 mm. Launder collection channels shall be designed to remove the water efficiently from the decanting orifices and shall continue to be a free down stream discharge at throughout rates of design flow as per data sheet considering 20% overload.

xviii). SLUDGE SCRAPER:

The sedimentation zone floor shall be scraped by a rotating scraper to progressively clear the sludge to the tank centre for collection the bridge shall rotate along perimeter, running on a circular steel rail by means of a perimeter drive unit. The rubber tyre types shall not be offered. The minimum driving horse power at the rack

shall be 3 HP. (Minimum). Bidders should note that high standard of machine and structural rigidity is required. The design life shall be at least 20 years.

xix). VARIATION IN TENDERED SCRAPER DESIGN:

Tendering contractors may, if appropriate to their own particular clarifier design, offer a scraper mechanism designed to jointly clear both the sedimentation zone and the area below the flocculation zone.

xx). FLOOR FINISH TO TANK:

The final finish to the tank floor shall be specified by the contractor with his tender. He shall submit the civil works procedure for applying a cement screed incl. Water proofing compound of a suitable thickness to the structural concrete base slab in order that the surface finish may be laid to profile matching the surface finish may be laid to profile matching the scraper blades.

xxi). SETTLED WATER OUTLET TO FILTERS:

Settled water from the clariflocculator shall be fed to the filters by extending the decanting launders till the common filter influent channel/chamber. A free fall is envisaged between the extended launder and common filter influent channel. The velocity of water in outlet conduit should not be more than 0.4 M/Sec.

xxii). SLUDGE REMOVAL:

Sludge shall be continuously removed from the clarifier by telescopic draw off valve during normal operation. The telescopic valve shall be operated from head stock at the peripheral walk-way level. It shall be constructed with cast iron body fitted with bronze guides. A telescopic valve stand pipes shall be fitted with best key level by pass drainage valves. The contractor shall state in his tender the anticipated average sludge draw off rate, the peak rate achievable and capacity of his proposed telescopic draw off units.

xxiii). TANK DRAINAGE:

For maintenance purposes the contractor shall provide the necessary arrangements for draining the clarifier by gravity.

xxiv). PERIMETER WALKWAY:

The contractor shall arrange a perimeter walkway to enable works operational staff to inspect the decanting orifices. These walkways may be founded on finished ground level or be cantilevered outwards from the tank wall, the walkways shall be continuous and level with the top of the sludge draw off chamber facilitating access to the draw off head stock, and shall be provided with hand rails on outer side.

xxv). EMERGENCY STOP OF MACHINERY :

The contractor shall provide appropriately located emergency stop buttons on the clarifier which when pressed shall immediately cut off all electrical power to the flocculator, scrapper and rotating bridges. Reset shall only be from the clarifier machinery control disc. At least two stop buttons one at the centre of the access bridge and the other on the access way to the clarifier at the outer tank wall shall be provided.

xxvi). CLARIFIER TANK MACHINERY AND CONTROL:

The scrapers, flocculator, blades and the rotating bridges supplied by the contractor shall generally be manufactured in steel, painted and protected. All steel members of the bridge shall be painted and hand rails, scraper elements galvanized.

xxvii). ROTATING BRIDGE STRUCTURE :

The rotating bridge structure shall incorporate a walkway having a minimum effective width of 1.0 m, which shall be surfaced with M.S.chequered plate, painted black. The bridge shall be designed to take its own dead weight together with uniformly distributed super loading of 500 kg/m over the half span and width of the walkway bridge. Maximum deflection of the bridge under the specified loading shall not exceed 1/360 of the span. The bridge shall be so braced as to a limit lateral deflection to less than 8 mm, measured at mid span under full load conditions. A drawing to support the contractor proposal in this regard shall be submitted to the Engineer for approval.

xxviii). CONCRETE SUPPORT AND END CARRIAGE:

The bridge structure shall be supported at the centre of the tank by means of a substantial cast iron bearing assembly of the slowing ring type and incorporating trunion type mounting to accommodate vertical undulation of the traction wheels at the peripheral wall of the tank. The central bearing assembly shall be extended to a battery mounted at the convenient point above the walkway. Oil-fill and drain points, where applicable shall be extended to provide a convenient access for filling and drawing the system. Catch drains shall be provided under all oil and grease points to prevent spillage from reaching the water surface. The wheel carriage assembly shall be suitably proportioned to provide adequate stability to the rotating bridge structure while providing the substantial base for the motors, gear box, driving and idling wheels, shafts and bearings.

The wheel assemblies shall be so arranged as to provide the necessary adjustment of the radial and the cone angle. The wheel shall be designed to run on a circular steel rail without scuffing and shall be given long service or a continuous running basis.

The size and design of wheels and carriage shall be calculated to transit optimum tractive effort relative to the proportions of the scraper without producing wheel spin when the wheel path is subject to the climatic conditions which reduce the adhesion. Contractor's calculations for these shall be submitted with those specified before.

xxix). SCRAPER DRIVE:

The scraper drive shall comprise a direct coupled electric motor with reduction gear units.

The assembly shall be rigidly mounted and shall be completely weather-proof whole of it shall be adequately rated for continuous service in a water treatment works environment. All lubrication points and all necessary provisions shall be made for routine maintenance and for a prevention of oil and grease spillages. A deflector shall be provided and fitted to the leading edge of the driving carriage. It shall be angled at 45° and arranged to be adjustable to within 3 mm of the perimeter rail such that materials liable to foul the free passage of the wheel shall be deflected out of its way.

xxx). HAND RAILS:

The bridge shall have hand railing to both sides forming an enclosure at the centre in between. The finished height of the hand railing shall be 1 m above the walkway. The guards shall be provided and secured around the bridge walkway which shall be not less than 100 mm. High and 5 mm. Thick.

xxxi). BLADES AND FIXINGS:

Scrapers shall be arranged to give continuous and progressive scraping of the entire floor of the tank and the swept area of the successive blades shall overlap. The configuration of blades shall be designed to convey sludge and deposited suspended solids from the periphery of the tank and deposit it efficiently in the withdrawal hopper/sludge pocket. The No. And length of individual blades shall be at the discretion of the contractor. But the depth shall not be less than 300 mm. And the thickness not less than 6 mm.

The top portion of blades shall be folded forwards in the direction and overall proportions shall be such that individual blades shall maintain rigidity at all times. Renewable fabric reinforced rubber wearing strips of cross section not less than 12 mm. X 100 mm. Shall be fitted to each blades to provide a continuous contact surface which is adjustable for water. The materials chosen shall have shore hardness not greater than 40 and be manufactured from well proven compound details of which shall be submitted with the tender.

Backing strips shall be fitted to give support to the fixing of the rubber wearing strips and the assembly shall be secured by means of stainless steel bolts, S.S. 316 of not less than 10 mm dia. Appropriate washers shall be fitted beneath all bolt heads and nuts. The backing strips shall not project beyond the lip of the scraper blade and the

rubber wearing strips shall not project by more than 3 times their thickness. Drilling of scraper blades and packing strips shall be uniform about the centre to facilitate and to end reversal and complete replacement of rubbers to compensate for wear.

The upper most edge of the blades is mounted in such a way that they will at all times, be inclined slightly forwards in the direction of rotation.

Depending arm scraper plates shall be connected to the rotating bridge structure by an extension frame attached to the bridge structure or by means of tubular depending arms (or in equally robust alternative) of adequate proportions, which shall be capped or otherwise sealed at the ends.

Robust cast iron brackets with kunclee joints shall be used to connect the depending arms to the bridge structure and to the blades.

The top connections shall permit the blades to follow slight undulations in the tank floor. The bottom connection shall allow the blades to maintain contact with the floor throughout its length, while accommodating slight variations in the radial plane of the tank floor.

xxxii). FLOCCULATION ZONE ARMS AND SCRAPERS:

The flocculation zone arm and scrapers shall be arranged to suit the contractor's own specific requirements and shall be designed and constructed to similar standards as specified above (for outer scraper), and provide with similar features and fittings.

Central driven flocculators and scrapers shall be passed via a spun gear and ball slowing ring, running in a fully enclosed oil bath. The lower pivot around the central riser shall be constructed with atleast three bronze slipper bearings on a steel guide ring.

xxxiii). SLIP RING ASSEMBLY:

The electrical supply to scraper or flocculator driving motor shall be taken through a multi ring and slip ring collector unit mounted in a fully water proof enclosure. The unit shall be fitted at the centre of rotation of each scraper and shall be complete with necessary support brackets, Antirotation device. A suitable means of lubrication shall be provided and the covers shall have a suitable worded warning lable that the source of supply is to be switched off before removing the cover. The slip ring assembly shall be mounted above the top level of the tank walls. Sufficient rings shall be included to cover the mortar supply and any ancillary circuits.

xxxiv). MOTORS:

Scraper motors shall be of squirrel cage type, protected to IP 55 and shall be rated 25% above design maximum.

xxxv). STARTERS:

Unless otherwise specified the starters shall be accommodated within a fibre based kiosk in the building on the clarifier bridge.

xxxvi). **METHOD OF CONTROL:**

The flocculator and scrapers shall each be arranged for individual manual control. Where the tanks are elevated and access to the bridge is limited to one point of the periphery, the contractor shall provide a limit switch positioned on the peripheral wall which in conjunction with “Striller Mechanism” positioned in the bridge stop shall be driving mechanism in the “Park” selector switch shall be provided in the control panel which shall be located in a fibre glass kiosk on the approach walkway.

xxxvii). **METAL PROTECTION:**

All ferrous and Non-ferrous metals except stainless steel shall be suitably treated to prevent corrosion and weathering.

1.3.11 FILTRATION WORKS

i). **WORKS TO BE INCLUDED:**

The works to be included by the contractor in this section of the treatment process shall comprise of at least the following:

- a) Design and necessary arrangements for Dual media filter units.
- b) Design and necessary arrangements to distribute the flow between the filters, cleans, the filters, removing the back wash water and collect the filtrate flow for final disinfection.
- c) Design and necessary arrangement to construct the filtration works.
- d) Design and layouts for administrative purposes for the filter house and machinery shall be attached with the filter battery.
- e) Supply of filters with filtering media and the necessary machinery and equipment required for the filters.

ii). **BRIEF DESCRIPTION OF THE WORKS:**

Pressure Filter

The filter vessel for Dual Media Filter shall be in Mild Steel with a suitable thickness. The test pressure shall 1.5 times of working pressure (Minimum). The internal portion of the filter vessel shall be epoxy painted. Each filter shall be provided with drainage system consist nozzles with nozzle plate. The control valves of filter shall be electric operated butterfly valves with a provision of manual operation of valves. The filter's operation (service and backwashing) shall be automatic operation. The filter media shall be as per

the specification as describe above. The filter vessels shall be in MS with sufficient thickness. The drain system of vessel shall be nozzle type. Filter sand shall be free of clay, mica, shale, dirt, loam, organic impurities, and water-soluble iron and manganese. The silica content shall not be less than 95 percent. The weight loss on contact with 2 N hydrochloric acid shall be less than 2% after 24 hours

iii). GENERAL DESIGN CRITERIA AND FILTER TYPE:

iv). EXTENT OF WORKS:

Under this contract, the contractor shall supply required filter units and shall all the machinery. Equipment required for all the filter units.

Contractors design and installation shall be such as to enable the filter battery to filter water at a rate of design floe as per data sheet. In the event of conversion into dual media, filters at a later date, for this the shell design all the transmission system pertaining to filtration works, that is settled water channel, pure water channel, pure water gravity drain, all of the under drain system for throughout put rate of i.e. double the rate of design flow rate. Contractor's designs shall also be such as to enable the filter battery to be linearly extended at a later date with the minimum of interference to the works.

v). FILTER FEED:

Inlet flows to the filters shall be distributed along the length of the filter battery externally arranged in a reinforced concrete settled water common influent channel with a suitable arrangements of the enable the incoming flows to be divided equally between the two filters say an adjustable weir plate. Channels and associated chamber floors shall be given slope towards the drains and drainage valves. They if necessary shall be fitted with to stop or step irons for internal access.

vi). FILTER MEDIA:

vii). FILTER SUPPORT:

Filter sand shall rest on a gravel bed of not less than 0.40 m. Thickness in the event of piped under drain system, or any directly on the suspended floor in case of nozzled under drain system to suit a particular design.

viii). FILTER SAND:

Filter sand shall be of hard and resistant quarts or quartzite and free of clay, mica, shale, dirt, loam organic impurities, later soluble iron and manganese. Effective size shall be 0.45 to 0.70 mm. Uniformity coefficient shall not be more than 108 not less than 1.3. The weight loss or contact with N hydrochloric acid shall not exceed than

5% weight after 24 hours. Ignition loss should not exceed 0.7 percent by weight. The friability weight loss after mixing for 15 minutes (750 strokes) shall be less than 10% and for 30 minutes (1500 strokes) shall be less than 20%.

The specific gravity of the sand shall be in the range of 2.55 to 2.65 silica content should not be less than 90% wiring loss should not exceed 3% IS 8419 (Part-I) 1947: Filtration media. Sand and gravel may be referred for other details.

ix). AIR MAINS:

The Contractor shall feed air to the filter through a steel header, at a high level within the pipe gallery. Individual filter section suppliers from the air header shall be in flanged steel pipe work but the filter entry pot shall be a cast iron flanged piece, with integral puddle which shall incorporate a siphon and valving to exclude reverse water flows to the blowers.

x). WASH WATER MAIN:

Wash water supply pipe work shall be from elevated service reservoir as specified. Velocity in the header shall be designed to account for head losses arising in the future development & preferably shall not exceed 2.0 m/sec. The req. Valves and its chamber shall be also provided by the contractor at his own cost.

xi). WASTE WATER COLLECTION & DISPOSAL:

The filter back wash waste from each filter shall be collected in a common waste water channel connected in drainage system which is a part 7 parcel of filtration works. Care should be taken while designing the outflows about uniform collection sludge / muddy water as otherwise sludge pockets are likely to remain which will eventually clot the pipeline.

The final disposal leads to the natural drain passing near by and all required piping, channel is to be designed and provided and constructed by the agency at his own cost up to 500 m length.

xii). lateral length:

The length of lateral on each side of manifold shall not be more than 16 times the diameter of laterals.

xiii). WASH WATER SUMP:

Wash water recirculation sump should be provided for all the Filter Plants irrespective of its capacity. The capacity of recirculation sump should accommodate back wash water of one Twin (Twin compartment) or two single beds + 10,000 litres.

Necessary pumping 88urbulenc including all accessories for recirculation back wash water pumping shall be provided by the agency.

1.3.11.1 Filtration Plant

The filtration system shall consist of horizontal Centrifugal type pumps filter feed pumps (working and 1 Stand by) and Dual Media Filter with 1 nos. of stand by filters, Filter Piping, Filter Valves, Filter Back Washing System with air blowers and backwashing pumps, with complete automation of filter operation (filtration, backwashing) through DCS.

Dual Media Filter

- i. Filtered water output - 1 MLD
- ii. Filters operation - 24 hrs.
- iii. Filtration Rate - $12 - 15 \text{ M}^3/\text{M}^2/\text{Hr}$
- iv. Backwash Rate - $35 \text{ M}^3/\text{M}^2/\text{Hr}$
- v. Air Scouring Rate - $40 \text{ M}^3/\text{M}^2/\text{Hr}$
- vi. Supporting Bed - Gravels
- vii. Sand Media - Fine Clean Sand as per IS 8419
- viii. Filter Under drain System : Filter Nozzles
- ix. Filter's Valves - electric operated butterfly valves
- x. Mode of Operation - DCS Based Auto Operation
- xi. Test Pressure- Min. 5.0 Kg/cm²
- xii. Free Board : 50 %

Sand Media

- i. Uniformity of Sand- 1.3 - 1.5
- ii. Effective Size - 0.7 mm
- iii. Depth of Sand - 700 mm (Minimum)
- iv. Supporting media - Gravels (Attrition Loss should be Minimum)

Anthracite

- i. Specific gravity - 1.50 to 1.60
- ii. Depth - 0.3 m (minimum)
- iii. Effective size - 1.0 mm
- iv. Uniformity coefficient - 1.3 to 1.5

1.3.11.2 Air Blowers

The Air blowers shall be designed for a suitable flow at suitable head of filter scouring. Two nos. (1 working + 1 Stand By) air blower shall be provided. The air blower shall be positive displacement type. Air blower will be provided with a suction air filter and silencer, pressure relief valve and delivery non-return valve. The air pipe to the filter shall be laid with an above the maximum water level of the filters and a vacuum breaker at the point to avoid backflow and siphoning of water in the blower. Pressure gauges with stop cock at the pressure side of the blowers shall also be provided.

1.3.11.3 Filter Backwashing Pumps

Horizontal centrifugal pumps (1W + 1 S) along with suitable induction motor coupled, suitable for filter backwashing shall be provided. The filter backwashing pumps shall be located at the filtered water sump.

1.3.11.4 Backwash water Recovery Tank

Design Parameters of Backwash water Recovery Tank

Parameters	Design Criteria
Capacity	To hold the backwashed water generated by the min. 2 Nos. filters
Qty.	01
Free Board	By the Contractor
Material of Construction of rungs	Encapsulated PVC
Hand Railing	32 NB SS 316 L
Settled Wastewater Recycle Pump	
Type	Submersible
Qty	2

1.3.12 Ultra Filtration Units

The material for membranes used shall be polymeric [regenerated cellulose, polyacrylonitrile, polyvinyl alcohol, polysulfone, polyethersulfone, cellulose acetate, cellulose triacetate, aromatic polyamide, polyimide, Polyvinylidene Fluoride] or ceramic [ceramic composites (zirconia on alumina)].

The module size, its pore size, operating and back flush flux rate, temperature stability, solvent resistance, bacteria inhibition and resistance to fouling of the membrane shall be suitable to cater to the required duty.

Adequate space shall be provided on the feed and reject side of the UF/MF skid to ensure easy loading and unloading of the UF/MF membranes.

However, the pre-treatment provided by the CONTRACTOR shall meet the feed water limiting conditions indicated by the membrane manufacturer. In case, the BIDDER feels that any additional treatment is required to meet the feed water limiting conditions, the same shall be included and indicated clearly in the BID with justification. Pre-treatment scheme shall be discussed and finalized during bid evaluation stage. In case these conditions are still not achieved during commissioning, the CONTRACTOR shall carry out the required modifications in the pre-treatment without any price implication.

A chemical cleaning system shall be provided if indicated in data sheet A. The chemical cleaning system shall comprise of a cleaning solution tank, a micron cartridge filter of 5-micron rating and SS 316 cleaning pump. The volume of cleaning solution tank shall be adequate to fill the volume of the UF/MF tubes to be cleaned at a time, UF/MF block piping, cartridge filter and piping of cleaning system. However, the cleaning solution tank shall be sized considering a 20% margin.

All the components of the chemical cleaning system shall be able to withstand extreme pH and temperatures up to 50°C.

The minimum instruments to be provided are listed in the data sheet A. The instruments such as rota meters for feed, reject and permeate and pressure indicators for feed, reject and permeate shall be located on the UF/MF skid such that all instrument have easy access and good visibility.

The UF/MF array design shall be such that the maximum feed flow rates and minimum reject flow rates per UF/MF tube are well within the values given by the membrane manufacturer.

1.3.13 Chlorination

Chlorine solution diffusers shall be supplied and installed at the dosing point.

Treated sewage shall be dosed with chlorine gas at concentrations not more than 10 mg/l. Effluent from the chlorine contact tank shall not have more than 1 mg/l of residual chlorine.

1.3.13.1 Chlorinators

- i). Vacuum type chlorinators shall be supplied with one duty and one standby unit.
- ii). Chlorinators shall be free-standing, floor-mounted, and shall have a turn down ratio of 10: 1 over the full range of works operation.
- iii). The dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10 mg/l scale and a manual dose setter over the complete range.

1.3.13.2 A: Motive water pumps and Injector

- i). Motive water pumps (1 working + 1 standby) shall be installed.
- ii). The pumps shall draw their supply from bore well/plant water supply.
- iii). The pumps shall be installed outside the chlorination room and shall be made from material resistant to corrosion by chlorine.
- iv). Two injectors shall be provided, each serving a duty / standby pair of chlorinators. The injectors shall be located near point of dosing i.e upstream of Chlorine contact tank.

1.3.13.3 B: Inline Vacuum/ventury type chlorine injectors

- i). In line Ventury type which shall mix Cl gas metered from Chlorinator into motive water from Booster Pump
- ii). All wetted materials shall be constructed of Grade 2 Titanium (unalloyed). The motor shall be chemical duty type.

1.3.13.4 Chlorine

Chlorine shall be supplied as liquid from nominal 1 tonne chlorine tonner.

1.3.13.5 Tonner Room

- i). Storage shall be provided for chlorine tonners sufficient for at least one month's usage at normal rates of application.
- ii). The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.
- iii). Tonners on line, tonners on standby and full and empty tonners, shall be stored separately in the tonner room.
- iv). Four sets of tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles. Tonner shall be provided with suitable capacity chain pulley block (Min. 2 Tonne)
- v). The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.
- vi). Operation of crane system shall be from the floor level using independent push button pendant controls operating at a 230 volt 50 Hz AC supply.
- vii). Two lifting beams shall be provided (a duty and a spare) and a one tonner weigher to be suspended from the crane hoist.
- viii). When the pressure in the duty chlorine tonner falls to less than 1 kg/cm² the automatic changeover device shall operate to isolate the empty tonner and to bring the full standby tonner on line.
- ix). A pit and alkali absorption system shall be provided to contain and neutralise chlorine in the event of a leak. The system shall comprise a pit located in the tonner storage room and accessible by the overhead crane system. The pit shall be surrounded with removable guard railing. The pit shall be kept full with a neutralising solution of lime. The pit shall be capable of holding side by side two chlorine tonners. A provision shall be made to drain the pit. Tonner shall be provided with suitable capacity chain pulley block (Min. 2 Tonne) also Neutralization Pit for the suitable capacity to handle the leakage of Chlorine Tonner to be constructed in the vicinity of the tonner in Chlorine room.
- x). Special consideration shall be given to any floor drainage system in the tonner building; adequate traps shall be provided to ensure that chlorine gas cannot escape. All leader tubes carrying cables or pipes out of the building shall be sealed at either end to prevent any chlorine gas leaking out.

1.3.13.6 Chlorination Room

- 1) The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access.
- 2) Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

1.3.13.7 Chlorine Leak Detectors

- i). One Chlorine Gas Detector shall be provided with Single Detection Cell located in Chlorine Tonner room.
- ii). Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Hindi and English.

1.3.13.8 Ventilation System

- i). Each area where chlorine is stored or used as gas or liquid shall be provided with a forced ventilation system. Air intakes shall be sized to allow uniform ventilation and positioned to prevent possible recirculation. Exhaust air shall be ducted from low level and discharged at high level.
- ii). An air change rate of four per hour under normal condition and a minimum of twenty changes of air per hour under shall be used in the event that a chlorine leak is detected.
- iii). Exhaust fans shall be heavy duty industrial pattern manufactured from chlorine resistant materials.
- iv). Ductwork shall be manufactured from U-PVC extruded sheets or circular sections.
- v). Ducts shall be designed in accordance with relevant Indian standard specifications.

1.3.13.9 Safety Equipment

- i). Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.
- ii). The equipment shall include:
 - 1) Two sets of approved self-contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with three 1200 litre capacity, 140 mm diameter, air tonners.
 - 2) Two No of Canister type Gas Mask

- 3) Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline with Suitable Air Tonners along with airline hose.
- 4) Emergency Repair Kit suitable to handle Gas leakage from Chlorine Tonner
- 5) Two 'instant action' resuscitators.
- 6) Four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.

Note- All the Safety Equipment should be as per the applicable IS standard for Chlorination as per the CPHEEO and in addition to above list as per the requirement.

- iii). Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC coated steel cabinet in approved locations on the outside of the building.
- iv). Two emergency showers shall be provided and shall be installed outside on either side of the tonner room.
- v). Each shower shall be operated automatically by a quick acting hand or foot valve.
- vi). Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers.
- vii). Water for the showers, etc, shall be drawn from the service water supply.
- viii). A telephone will be provided close by outside the building for emergencies.

1.3.13.10 MCC Power & Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process.

1.1.2 Sludge Handling

As sludge generated from different process units depending upon the process adopted, it is advised to provide sludge handling units and equipments like sludge thickeners, centrifuge, combo-machine and other ancillary units which is suitable for the process and which is sustainable from Operation & Maintenance point of view. The units and equipments shall be selected accordingly which occupies less power, space, chemicals and maintenance.

1.3.13.11 Gravity Thickeners with Dewatering unit

Circular (radial), fixed bridge, central turn table type or peripheral drive type picket fence, collecting effectively with proper circumferential speed, a clarifier shall be provided. The

clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

- (a) The circular reinforced concrete thickeners tapering at bottom shall be provided for thickening process. The sludge laden suspension from Waste water balancing Tank shall be fed to thickeners.
- (b) Design shall be such that the sludge can become compacted and can be extracted from the bottom. Interstitial liquid flows through peripheral weir at top. Tanks shall be deep enough to allow the sludge to settle. At least 50 cm freeboard shall be provided.. Provision shall be made to remove the sludge from top if there is a serious risk.
- (c) Provision shall be made for collection of thickened sludge and pumping it to Centrifuge.

A full diameter bridge with central drive shall be provided with: central platform for the installation of the scrapers and their drives and for the local control panel; a radial scraper system with bottom scraper blades, suspended on the bridge.

- (a) The thickeners shall have a full diameter fixed bridge complete with 1200mm walkway for personnel access to the centre, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing, walkways, access steps etc shall be galvanized. Handrails shall be of tubular construction and made of 32NBpipes.
- (d) The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners.
- (g) The electric motor, gearbox etc., shall be provided with a sunshade.
- (h) The fixed bridge, hand railing, access steps and the feed well shall be galvanized steel. The main drive shall be cast Iron construction and shall be enclosed in a dustproof enclosure with oil bath lubrication. All underwater hardware shall be of SS316.

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- (i) Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop pushbutton shall be provided.
 - (j) The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.
 - (1) Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc.
 - (2) Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. And also the calculation for drive head selection including the Torque Rating.
 - (k) V-notch weir in Reinforced fibreglass construction of size minimum 5mm thick and 200 mm wide shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means SS316 grade clamping plates and fasteners.
 - (l) The hydraulic equipment will consists of the DI inlet pipe(runs along the bridge) to the central feed well of the thickener; sludge draw-off pipe with an manual & Motorized Knife Gate valve (in SS CF8M material of construction) for intermittent operation according to an adjustable timer; a drain pipe with manually operated gate valve for the complete emptying of the unit; a discharge pipe/channel from the peripheral collecting channel to the main channel leading to the Supernatant sump. The sludge thickener mechanism shall be generally in MS galvanized construction, suitable for installation in a circular RCC tank and shall include the following:
 - a. Mechanism support beam spanning the diameter of the tank.
 - b. Walkway and handrail from the edge to the centre of the tank.
 - c. Drive mechanism with internal gear type.
 - d. Reduction gear box.
 - e. Chain and sprocket with guard.
 - f. Central shaft with scraper arm and picket fence.
 - g. Skimmer Scum Baffle and Scum trough.
 - h. Overflow weir:
 - i. Vertical pickets.
 - j. Torque Indicating Device.
-

k. Overload Alarm protection.

1.3.13.12 Dewatering Centrifuges

- i). The Dewatering Machine and its peripheral equipment shall include but not necessarily be limited to the following;
 - 1. Powder or liquid Coagulant storage tanks.
 - 2. Mixers and solution tanks.
 - 3. Coagulant service tanks.
 - 4. Supply line & flush line.
 - 5. Chemical feeding pumps.
 - 6. Water supply pumps.
 - 7. Sludge feeding pumps.
 - 8. Dewatering Centrifuge
 - 9. Belt conveyor.
 - 10. Cake hopper.
 - 11. Flow meters for feeding Sludge, and for feeding chemical solution.
 - 12. Control valves on sludge feeding line, and on Chemical feeding line.
 - 13. Drain system
- ii). Dewatered cake shall be conveyed by a belt conveyor to cake hopper for carrying out for reuse.
- iii). To select the type of dewatering machine, Contractor shall provide technical information to show client that performance to obtain his approval in advance.

Decanter 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.

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.

i). 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.

ii). 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.

1.3.13.13 Screw Press

The screw press should be with a conical screw shaft and cylindrical sieve consisting of three treatment zones: inlet and drive zone, three-part thickening and dewatering zone, and press zone with pneumatic counter-pressure cone.

The screw press must be fed with flocculated sludge of sufficient stability. The first part of the screw press should be provided with large free screen surface so that the free supernatant liquor is quickly removed from the sludge.

The pressure probe should be provided in the inlet to protect the plant against excessive primary pressure and consequently excessive pollution of the filtrate liquor and excessive residual moisture in the sludge outlet.

The second part of the screen is to be designed in such a way that the volume of material between the screw flights is reduced by the conical screw and the sludge is pressed against the inner screen surface so that the sludge is dewatered, with a continuous reduction of the filter cake thickness. The screen apertures should be much smaller in this screen section.

In the third part of the screen the residual water will be pressed out of the sludge, at a minimum filter cake thickness, by the pneumatic counter pressure cone at the press discharge. Depending on the type and consistency of the sludge flocks the pressure applied on the sludge is to be varied infinitely.

The conveying screw should push the dewatered sludge past the pressure cone into the discharge chamber.

The sludge residence time in the screw press and thus the filtration time should be adjustable to individual requirements by adjusting the rotational speed of the screw shaft.

Brushes should be fitted on the flights to ensure permanent automatic sieve cleaning from inside.

Intermittent cleaning of the sieves from outside is to be accomplished by a spray bar. The spray bar should be stationary mounted whereas the screen basket is a rotating element.

For the purpose of cleaning, the feed into the screw press is to be temporarily stopped and the screw shaft should rotate in reverse. The flexibly supported screen drum should perform one complete rotation passing by the spray nozzle bar to clean the complete screen surface.

In pressing mode, sludge feeding should start again and the screw shaft should rotate forward. The screen basket should rotate until arrested by ratchets anchored in the casing. Thus the pressing process should continue.

Electrical appliances on the machine:

Drive motor of screw

Solenoid valve in the wash water connection

Pressure sensor on the sludge inlet housing

Pressure switch for compressed air supply (optional)

Material of construction: Screw Press should be made of stainless steel material AISI 316 (or similar) and pickled in an acid bath

Accessories for Screw Press:

Polymer injection and mixing device

For continuous mixing of coagulants and sludge, comprising of polymer injection ring with integrated distribution channel and 4 injection nozzles. Double sealed cover provides easy access to distribution channel and nozzles.

One-piece blockage-free design, self adjusting mixing energy via lever and adjustable weight. Weight loaded mixing valve with inspection opening.

Nominal width	DN 65, DIN 2501
Fitting length	280 mm
Total length	660 mm incl. Lever and weight
Polymer connection	DN 25 socket
Housing	Cast iron, RAL 5015
Movable parts	AISI 420

Supercharge reactor

For optimal flocc formation downstream the polymer injection and mixing unit. Horizontal reactor shaped to provide defined turbulence and pressurized feeding of the screw press.

Reactor length	4000 mm
Diameter	250 mm
Height adjustment range	180 - 200 mm
Volume	approx. 160 l
Inlet flange	DN 65
Outlet flange	DN125

Material of Construction:

Reactor completely made AIS 316, including height adjustable support legs.

Pressure adjusting system

To regulate the pneumatic pressure cone. The system allows a fine adjusting of the compressed air. Lack of air is electronically detected and the cone can be moved backwards by hand lever valve.

Supply should include pressure sensor and a hand lever valve wired ready for connection on a galvanised plate.

L x H: 334 x 355 mm

Air inlet (6-8 bar): 1 x 10 mm push-in fitting

Air outlet: 2 x 10 mm push-in fitting

Electronic pressure switch with 2,5 m connector cable for voltage supply (24 V) and PNP switch output.

Electrical control panel for Screw Press

Control panel suitable for wall mounting in compliance with UVV and VDE standards. Complete with all components required for fully automatic plant operation, switch on/off of individual drives via function keys on control unit, motor protection relay, overload protection, fuses, relays, lockable mains isolator, socket-power unit 24 V DC. Display on control unit of operating hours, operating and fault signals, run times.

Control panel:

Painted steel RAL 7035

Protection grade: IP55

To control the following units:

1 Screw Press incl. Power element (frequency converter:)

1 flocculation reactor stirrer incl. Power element (frequency converter:)

1 filling level probe in flocculation reactor to prevent reactor overflow

1 washing system control

- 1 release/fault thin sludge pump
- 1 release/fault coagulant agent pump

Frequency convertor

Designed in compliance with CE safety and EMV standards

Convertor for integration in main control panel of the electrical switchboard comprising:

three-phase alternating voltage 3 x 380 / 460 V AC

typical shaft power PM,N = 3.0 kW

frequency f = 50 Hz

protection IP 20

integral class A EMI filter

control display

Compressed-air plant

Miniature compressor for compressed-air production and pneumatic regulation.

Type Piston compressor

Effective delivery: Q = 200 l/min

Max. Pressure: p = 10 bar

Reservoir volume: V = 24 l

Performance with 400 V AC: P = 1.1 kW

Protection grade: IP 54

incl. Maintenance unit and pressure regulating valve

1.3.14 Sluice Gate

1.3.14.1 Design requirement and construction features

The construction of the sluice gate shall be in accordance with the specification and generally as per AWWA C 560-00 / IS: 13349-1992 or other applicable standard. All sluice gates shall be of the rising spindle type. The sluice gates shall be capable of performing the duties set 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 heads required with a minimum safety factor of five.

1.3.14.2 Frame

Guide shall be bolted to the frame of 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 upon 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 surface on the slides.

Seating Faces

Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixing in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in the faces shall be of ample section and finished smooth.

1.3.14.3 Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing 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 screws and locknuts and so designed that they will remain in the fixed position after adjustment.

1.3.14.4 Lifting Mechanism

Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required.

Lifting mechanism shall be suitable for operation by one man under all conditions. lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.

The manual operation shall be of the hand wheel crank operated type and shall have a lift nut threaded to fit the operating stem. Crank shall be removable. Ball or roller thrust bearing shall be provided above and below the flange on the lift nut to take the load developed in opening and closing the gate with torque of 14 kg-m on the crank. Fitting shall be provided to lubricate gears and bearing.

The design of the lifting mechanism of the hand operated gates shall be such that the slide can be operated with a torque of not more than 7 kg-m on the operator after the slide is unseated from wedges based on the operating head. the maximum crank radius shall be 380 mm.

All gear and bearings shall be enclosed in cast iron housing with labyrinth seals. The lifting mechanism shall be with a cast iron pedestal, machined and drilled to receive the gear housing and suitable for bolting to the operating floor. The gates shall close with clockwise rotation of the crank. The direction of rotation to close the gate shall be indicated on the lift mechanism.

A suitable means shall be provided for lubricating the stem threads directly adjacent to the lift nut. An inspection cover shall be provided to access the lift nut and gearing.

Stem shall be provided with a GI pipe cover shall be fixed to the headstock.

Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

1.3.14.5 Wall Thimbles

Wall thimbles shall be made of CI and shall be supplied along with the gate. 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 shall not be less than 300 mm.

To permit entrapped air to escape as the thimble is being encased in concrete, holes not lesser than 35 mm diameter 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.

1.3.14.6 Lifting Lugs

Lifting lugs shall be provided for all gates.

1.3.14.7 Flush Bottom Seal

When sluice gate are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.

A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.

Suitable arrangement shall be made for on all the sluice gates or actuators such that the portable electrical actuator is capable of operating all sizes of sluice gates.

One No. of portable type electrical actuator for closing and opening of sluice gates shall be provided at each STP, so that the closing and opening operation time shall be maximum of 10 min.

Suitable arrangement shall be made on all the sluice gates or actuators such that the actuator is capable of operating all sizes of sluice gate, under this contract.

Pipe hood shall be provided on the top of headstock to protect the spindle from damage dirt, dust, water etc. The hood shall be made of transparent fracture resistant polycarbonate material. The hood shall have vent holes to prevent condensation.

The material of construction of sluice gate shall be as follows:

Component	Material
Wall thimble	CI: IS 210 Gr. FG 260
Frame & Slide	CI: IS 210 Gr. FG 260
Seating Faces	SS : ASTM Countersunk Fixing A276 type 316
Wedge	CI: IS 210 Gr. FG 260
Stem	SS: ASTM extension A276 type 316
Stem guide bracket	CI: IS 210 Gr. FG 260
Stem nut	SS : ASTM A743 CF8M

Stem Coupling	SS: ASTM A276 type 316
Fasteners, Anchor	SS: ASTM A276 type 316
Lifting Mechanism, pedestal gear house cover and stem guide	CI: IS 210 Gr. FG 260
Lift nut	Bronze : ASTM B 148 (CA 952, CA 954 or CA958)
Headstock Body	CI: IS 210 Gr. FG 260

1.3.15 Open channel Gates

The manufacture of open gate channel shall be in accordance with manufacturer's standard.

All open channel gate shall be of the rising spindle type and manually operated.

Open channel gates shall be tested as per manufacturer's standard.

The open channel gates for pumping station shall be CI sluice gates. All other gates shall be of marine grade aluminium alloy gates.

The material of construction shall be as follows.

Components	Material	Specification	Grade
Gate frame, Shutter, headstock, Flush bottom seal support bar, stop nut	Cast Iron	IS 210-1993	FG:260
Sealing Faces / Seat Facings	SS	ASTM A276	AISI: 316
Resilient rubber seal	Natural Rubber EPDM Rubber Neoprene Rubber		
Seal retainer bar	SS	ASTM A276	AISI: 316
Stem/Spindle	SS	ASTM A276	AISI: 316

Operating Nut/Stem nut	Leaded Tin Bronze	IS:318-1981	LTB 1, LTB 2
Fasteners	SS	ASTM A276	AISI: 316
Anchor Bolts	SS	ASTM A276	AISI: 316
Yoke	MS	IS: 2062-1992	Grade A

1.3.16 Submersible Mixers

- i). The submersible mixer shall be installed in the Anaerobic and anoxic zones, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec.
- ii). The mixer shall have a self-cleaning propeller optimised for effective mixing and vibration-free running, and required power shall be at least 10Watt/m³ of tank volume.
- iii). The mixer shall be driven by a high efficiency 3 phase motors IP68 Class F. Motor shaft and rotor shall be dynamically balanced.
- iv). Bearings shall be lubricated-for-life with a calculated life of more than 100,000 operating hours.
- v). The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones.
- vi). The mixer shall be provided with the following :
 - (1) Lifting frame with a winch which can be dismantled, free standing with adjustable boom length.
 - (2) Mounting socket for free standing hoist suitable for wall mounting.
 - (3) Guide for floor fixing components and support brackets for wall mounting.
 - (4) Stainless steel rope for raising and lowering the mixer.
 - (5) Rope block for holding the stainless steel rope where the lifting frame is used in different locations.
 - (6) Support rope for reliable support and guidance of power supply cable.
 - (7) Support clamps and hooks to support the power supply cable in such a manner that it is not under strain.

The propeller, propeller shaft and motor housing shall all be of SS 316.

1.3.17 Mechanical Floating Mixer

(a) General

Mechanical floating mixer and related equipment accessories shall consist of a motor, direct-drive impeller driven at a constant speed, an integral flotation unit, and impeller volute.

(b) Performance

Each mixer shall have a zone of complete mix and a direct pumping with a recirculation. Complete mix shall be defined as maintaining biological suspension of all mixed liquor suspended solids with design MLSS or less without the introduction of air.

(c) Mixer Drive Motor

The motor shall be rated for 415 volt, 50 hertz, three-phase service. The motor shall be standard efficiency, vertical P base design, totally enclosed fan cooled TEFC, and generally rated for severe duty. The motor shall in all cases equal or exceed standard NEMA specifications. A minimum service factor of 1.15 shall be furnished.

The motor winding shall be non-hygroscopic, and insulation shall equal or exceed NEMA Class "F". A labyrinth seal shall be provided below the bottom bearing to prevent moisture from penetrating around the motor shaft. A condensate drain shall be located at the lowest point in the lower-end bell housing. Unit shall have a one-piece motor shaft continuous from the top motor bearing, through the lower bearing and down to and through the propeller. The shaft shall be manufactured from high quality stainless steel. Motor bearings shall be regreasable. Sealed bearings are not acceptable.

(d) Motor Mounting Base

The motor shall be securely mounted onto a solid 316 stainless steel base which is integral with the motor base extension. All submersed wetted motor mounting base components shall be constructed of 316 stainless steel.

(e) Floatation

Each unit shall be equipped with a modular float constructed of fiber reinforced polyester skin FRP or equivalent with a central float passage of a size to allow installation and removal of the pump impeller. The float shall be foamed full of polyurethane foam of the closed cell type, and shall be totally sealed to prevent the foam from being in contact with the external environment.

(f) Impeller

The impeller shall be designed to pump the liquid from near the surface and direct it down toward the vessel/basin bottom. The impeller shall be a two-blade marine type precision casting of 316 stainless steel and shall be specifically designed for the application intended. It shall be dynamically and hydraulically balanced. The propeller must be attached to the motor shaft with a hardened stainless steel pin and set screw. Impeller shall be capable of being reversed to cause back flow liquid movement without causing damage to the mixer chassis and without causing upflow liquid damage to the motor bearing and windings. No liquid spray or other liquid leakage upward onto the surface of the motor support surface or flotation chassis will be allowed.

(g) Intake Volute Assembly

The impeller shall operate in a volute made of 316 stainless steel plate

(h) Vibration

The entire rotating assembly including the motor rotor, shaft, shaft accessories, and impeller shall be dynamically balanced within 2.0 mils peak-to-peak horizontal displacement measured at the upper and lower motor bearing. Measurements shall be taken at a frequency equivalent to the motor RPM. Measurements shall be taken with the motor in a vertical, shaft down position with the entire power section mounted on resilient pads.

(i) Cable Mooring System

Each unit shall be provided with a maintenance cable mooring system complete with mooring cable, clips, and thimbles, quick disconnects, anchors, and extension springs as shown on the drawings. Mooring cable, anchors, and hardware shall be 316 stainless steel. Field attachment of mooring points to the tank shall be the responsibility of the installing contractor.

(j) Cable Mooring Electrical Service Cable

Each unit shall include conductor power cable wired into the motor conduit box and terminating at the basin wall. Electrical cable shall be supplied with kellems grips at the motor and basin wall terminations. Electrical cable floats for flotation of electrical service cable shall be provided. Attachment of cable and supply of junction box/disconnect at the basin wall shall be the responsibility of the installing contractor. 316 stainless steel adhesive anchors for attachment of mooring system components to the basin wall shall be provided.

1.2 Pumps

1.3.18 Dry Pit Pumps

1.3.18.1 General

The total head capacity curve shall be continuously rising towards shut off with the highest at shut off.

- i). Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.
- ii). Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dB(A) at 1.86 M at sites. Vibration shall be limited to class II C of BS 4675/ zones A & B of ISO 10816-1The pump set shall be suitable for starting with discharge valve open or closed.

- iii). The pump set shall be capable of withstanding accidental rotation in reverse direction.

1.3.18.2 Features of Construction

- i). Pump shall be centrifugal, back pullout, single stage type.
- ii). Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed so as to allow free passage of solids. The volute tongue shall be straight across and filed to a smooth rounded edge. Casing shall be provided with wearing ring.
- iii). Hand hole shall be provided in the casing to allow easy access to the impeller as well as to the casing throat. Casing drain connection with stainless steel collared plug shall be provided.
- iv). Impeller shall be non clog type with smooth blunt edges and large water ways so as to allow free passage of the 50 mm size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy material.
- v). The critical speed of the rotor shall be at least 30% above the operating speed. Complete rotor shall be balanced dynamically as per ISO 9906
- vi). Replaceable shaft sleeves shall be provided and shall be securely locked or keyed to the shaft to prevent loosening. The surface hardness of the shaft sleeve shall be minimum 400 BHN.
- vii). 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.
- viii). Stuffing boxes shall be of such design that they can be repacked without removing any part other than gland and lantern ring. Stuffing box drain with pipe connection shall be provided at the lowest point so that no leakage accumulates in it.
- ix). Lantern ring shall be sandwiched between packings and shall be easily removable. Lantern ring shall be of axially split type. Grease shall be used for stuffing box sealing. Water will not be available for this purpose.
- x). The pump and motor shall be coupled through a flexible coupling. The motor shall be mounted directly on pump casing.
- xi). It should be possible to lift the complete pump vertically through the opening provided in the motor floor level in the pumping station.
- xii). Tappings shall be provided at suction and discharge nozzles for pressure gauge connection. Water flushing arrangement shall be provided for cleaning of sludge pipe line at its delivery side.
- xiii). Impeller wear ring hardness shall be min 50 BHN higher than that of Casing wear ring.
- xiv). The material of construction for Centrifugal Dry Pit Pump shall be as follows :

Sr. No.	Component	Material	
		Non-clog type	For clean water (for service water etc)
(i)	Impeller *	Stainless Steel : ASTM A 743 CF8M	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2%

Sr. No.	Component	Material	
		Non-clog type	For clean water (for service water etc)
			Nickel, or better
(ii)	Casing *	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel
(iii)	Shaft*	Stainless Steel : BS:970 Gr 431 S29	Carbon steel or better
(iv)	Shaft sleeve	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN
(v)	Casing ring	Stainless Steel : ASTM A 743 CA 15	Stainless Steel : ASTM A 743 CA 15
(vi)	Impeller ring	Stainless Steel : ASTM A 743 CA 15	Stainless Steel : ASTM A 743 CA 15

* Material test certificates shall be furnished by the Contractor

1.3.19 Submersible Pumps – General

Submersible pumps shall be of the single entry design supplied complete with boltless self-aligning duck-foot assemblies giving automatic connection to the discharge pipe work.

The total head capacity curve shall be continuously rising towards the shutoff with the highest at shutoff.

Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

The pumps shall be designed to handle solid sizes of up to 80 mm.

Pumps shall run smooth without undue noise and vibration.

The pump set shall be suitable for starting with discharge valve open and/or closed.

The pump set shall be capable of withstanding the accidental rotation in reverse direction.

Construction Features

- i). Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, single stage type.

- ii). Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.
- iii). Double mechanical seal shall be provided to protect the motor from ingress of liquid along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. Sensors are to be provided to detect if leakage of liquid into oil housing is above 30% concentration.
- iv). Double mechanical seals shall be provided to protect the motor from ingress of sewage along the shaft. the preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection.
- v). Impeller shall be non-clog open/semi open type for raw sewage and sludge application and enclosed type for clear water/treated sewage / filter rate pumping application with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials. The number of impeller vanes for pumps up to 1000 m³/hr shall be limited to two and shall be limited to three for the pumps higher than 1000 m³/hr.
- vi). The critical speed of the rotor shall be at least 30% above the operating speed.
- vii). Pump sets shall have double bearings. the bearing life shall be minimum 40,000 hrs of operation.
- viii). Each pump shall be complete with a CI delivery connection arrangement for fixing to the concrete floor of the suction well. All necessary SS fixtures required for guiding the pumps during lifting/lowering shall be provided. The installation shall facilitate automatic installation and removal of pump without a person entering the wet well. Each pump shall be provided with a SS-316 lifting chain with suitable provision for engaging the hook of the crane at 1 m interval.
- ix). Each pump shall be provided with an automatic coupling device for attaching the crane hook to the pump at low level, even whilst the pump is submerged, without the need for personnel to enter the wet well. This automatic coupling devise shall easily and automatically couple and uncouple the hoist hook and be complete with necessary accessories. All links and cables shall be multi-stranded SS.
- x). The submersible pumps shall be suitable for operation with or without submergence.
- xi). The pump shall start and stop automatically based on the level in the wet well.
- xii). The synchronous speed shall not exceed 1500 rpm at 50 Hz supply.
- xiii). The material of construction for submersible pumps shall be as follows:

S. N.	Component	Material
1	Impeller	SS : ASTM A 743 CF8M
2	Casing	CI, IS: 210 Gr FG 260 with 1.5 to 2 %

		Nickel
3	Shaft	SS : BS:970 AISI Gr 316
4	Bush	Bronze IS 318 Gr LT B2
5	Guide Rail Pipe	SS : BS 970 AISI Gr 316
6	Fasteners and Foundation Bolts	Ss : BS:970 AISI Gr 316

Material test certificates shall be furnished by the Operator and shall have the approval of Engineer.

The submerged cable shall be a multi-core flexible cord, Vulcanized rubber insulated with tough rubber sheath and outer PCP sheath to BS 6500.

Where both thermal protection and moisture-sensitive devices are incorporated within the pump, both devices shall be brought out via separate conductor within the motor cable, although one such conductor may be common.

1.3.20 Centrifugal Pumps

- i). Centrifugal pumps shall have head/quantity characteristics which fall continuously from the maximum pressure at closed valve conditions and which are steep in order that variation in head shall have a minimal effect on the quantity discharged.
- ii). The design speed of any pump with a duty flow greater than 20 l/s shall not exceed 1500 rpm. Pump motor rating shall exceed the maximum pump power consumption over the operational range of the pump by at least 10%.
- iii). Waterway through the pump shall be smooth in finish and free from recesses and obstructions. Impeller passageways shall be as large as possible. The leading edges of the impeller vanes shall be rounded and smooth.
- iv). Water velocities in the pump suction side shall not exceed 1.5 m/s and on delivery branches of a pump the velocity shall not exceed 2.0 m/s when the pump is operating within its specified duty range and within this working range there shall be no discernible noise due to hydraulic turbulence or cavitations within either the pump or its associated pipe work and valves.
- v). The NPSH requirements of the pumps, based on the 3% output drop criterion shall be at least 2 m less than the NPSH available at every working condition.
- vi). The velocity of vibration shall be within 4.5 mm/sec. Combined noise level of pump motor system shall be limited to 85 dB(A) at a distance of 1.85 m from the equipment, at manufacturer's works / free field condition at site after erection.
- vii). The pump shaft shall be of SS BS:970 Gr 410S21 compatible with the impeller which shall be of stainless steel ASTM A743 CF8M and the impellers and shaft sleeves

shall be secured to the shaft by means of a key/s. The impeller retaining nut shall be fitted with a locking device. The pump casing shall be of cast iron to IS 210 Gr. FG 260, wearing rings shall be of bronze to IS: 318 Gr. LT B2 and shaft sleeve shall be of SS ASTM A 743 CA 15.

- viii). All parts exposed to wear shall be adequately protected by means of renewable sleeves, bushes, wear rings etc. which shall be arranged for easy inspection, adjustment, or replacement without removal of the pump casings, pipe work etc, or the need to disturb the drive shaft alignment.
- ix). The pump thrust shall be taken by a combined thrust and radial type bearing assembly capable of taking the weight of the moving parts and the hydraulic load under all conditions of the operation with minimum life of 100 000 hours.
- x). Bearing cooling arrangement if used shall be designed on the closed-circuit principle; open discharge of cooling water into the pumping station drainage system is not permissible.
- xi). The pump casing and other parts of the pump subjected to pressure shall be hydraulically tested by the manufacturer to at least one and half times the maximum working pressure.
- xii). Integral inlet & discharge flanges shall be provided and integral lifting lugs shall be incorporated.
- xiii). Facilities shall be provided for the removal of air during priming and for draining.
- xiv). Glands may be fitted with mechanical seals or conventional soft packing. The gland arrangement shall be designed for easy adjustment and removal of the seal.
- xv). When soft packed glands are used suitable means shall be provided for collecting and preventing splashing of the gland leakage water.
- xvi). Drainage and gland leakage water shall be piped into the building drainage system.
- xvii). The shaft of the pumps fitted with conventional packed glands shall be fitted with removable gland sleeves.
- xviii). The rotating element of the pump and the motor shall be readily removable from the pump casing without the need to disconnect the adjoining pipe work.
- xix). Rotating assemblies of the pumps of 100 mm dia. inlet and over shall be statically and dynamically balanced and shall be designed so that the first critical speed is at least 50% greater than the maximum operating speed.
- xx). Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.
- xxi). On pumps of 75 mm inlet and over, tapping shall be provided at both the suction and discharge flanges of suitable size for pressure gauges.

1.3.21 End Suction Pumps

- i). 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. These types of pumps shall be used for filter backwash, Chlorination motive water and service water pumping applications etc.

- ii). The dimensions of the pump shall be metric confirming to BS 5257 or its equivalent standard. Flanges shall conform to BS EN 1092-2/BS 4504/ IS 1538.
- iii). 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.
- iv). The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.
- v). 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.
- vi). The speed of any pump shall not exceed 1500 rpm.
- vii). Glands may be fitted with suitable mechanical seals or conventional soft packing. The gland arrangement shall be designed for easy of adjustment or removal of the seal or packing material. Shafts shall be sleeved around the area of the gland when soft pack gland are used.
- viii). Flushing facilities shall be provided for mechanical seals or packed glands where pump fluid may be contaminated with abrasive material. Where soft packed gland are used, means shall be provided for collection of the gland leakage water, which shall be piped into the drainage system through adequately sized ports.
- ix). Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.
- x). 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.
- xi). Tapping shall be provided at both the suction and discharge flanges for pressure gauge equipment.

1.3.22 Pump performance Guarantees

- i). The pump performance guarantee shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's work and shall obtain approval of engineer.
- ii). The pump shall operate at its design point within acceptance tolerances for flow rate and total head laid down in BS EN ISO 9906:2000.
- iii). Each pump shall be tested at the manufacturer's work in accordance with BS EN ISO 9906:2000 or other relevant standards in conjunction with one of the contract motors.
- iv). This test shall be carried out on at least one pump set using the flexible coupling and contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.
- v). Where similar drive shaft arrangement have been installed by the operator and have been proven satisfactory in service this requirement may be withdrawn subject to the approval of the engineer.
- vi). A test shall be carried out of the performance from closed valve to the maximum quantity that can be delivered under abnormally low discharge heads.
- vii). Sufficient reading shall be taken at each test to produce accurate curves of the heads, flow, pump speed and power required at pump coupling throughout the operating range of the pump.

- viii). Vibration and noise dB(A) levels shall be measured and shown to be acceptable and shall have Engineer's approval. The operator shall have engineer approval and provide acceptable test certificates, showing the NPSH requirement for the pump is at least 2m less than the NPSH available under all working conditions.
- ix). In the absence of the approved test certificates the supplier shall carry out a test on one pump of each type to verify the NPSH requirement based upon the 3% output drop criterion and shall taken approval of Engineer.
- x). The certificates shall be submitted to the Engineer immediately following each of the test mentioned above. Performance curves shall also be incorporated in the operation and maintenance manual.

Single Pump Operation

- i). Head / Quantity Curve
- ii). Motor kW input/Quantity curve
- iii). Overall efficiency/quantity curve
- iv). NPSH required/quantity curve
- v). Vibration and Noise dB(A) levels.

Parallel Pump Operation

- i). Head / Quantity Curve
- ii). Motor kW input/Quantity curve
- iii). Overall efficiency/quantity curve
- iv). NPSH required/quantity curve
- v). Vibration and Noise dB(A) levels.

1.3.23 Progressive Cavity Pumps

- i). These pumps shall be used for handling thickened sludge transfer/feed applications.
- ii). Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pumps to give a uniform positive displacement.
- iii). Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion resistant shroud shall be fitted to prevent fibre build-up on the shaft. Enlarges inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris.
- iv). The shaft bearing shall be positively isolated from the fluid being pumped.
- v). The rotor material shall be selected and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome or other approved coating shall be not less than 250 micron thickness and shall be diffused in to the base material.

The rotor shall generally be single stage and shall incorporate not less than 3600 of twist, but for high-end applications, it may be necessary to use more than a single stage. the stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped.

- vi). Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.
- vii). Pumps shall normally be driven by a fixed-speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in-line on a common base plate. Alternatively, the drive motor may be top mounted above the pump to minimize floor area, and shall be connected by external V-belts and pulleys. V-belt drive shall have full guards of the type that allow the belts observed without removal of the guard. Facilities shall be provided for ready adjustment of belt tension.
- viii). Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections. All motor enclosures shall be provided with ingress protection to IP55. Motor anti-condensation heaters shall be provided and shall be suitable for use on a 220V single phase, 50Hz supply.
- ix). All bearing shall have a B10 design life not less than 40,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading, pumps shall be fitted with individual dry-running protection to initiate pump trip. Dry-running protection by 'under-current' monitoring of 'pipeline-intrusive' device shall not be used.

Material of Construction

Component	Material
Pump housing	CI IS 210 Gr. FG 260
Rotor	SS AISI 316 (hard chrome Plated)
Shaft	SS AISI 410 (hard chrome Plated)
Stator	Nitrite Black
Type of drive	V belt & pulleys
Base plate	MS Fabricated

Seal Type	Gland Packing (Asbestos free)
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1.3.24 Chemical dosing Pumps

- i). Chemical dosing pumps shall be piston diaphragm or mechanical diaphragm type as specified. Pump may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute. Pump, motor and driving arrangement shall be mounted on a robust combined base plate.
- ii). 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.
- iii). 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 step less 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.
- iv). The normal operating range of dosing pump shall be not less than 6:1.
- v). Mechanical Diaphragm: Diaphragm rigidly coupled to the drive train. Single suction pumps and discharge valves. Glandless. Accuracy: 3% of stroke.
- vi). Piston Diaphragm pumps: Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: 2% of the stroke.
- vii). Material shall be selected to suit the chemical being pumped. Liquid end shall be polypropylene, AISI 316 SS, Glass or Hastelloy C. Diaphragm material shall be butyl rubber, PTEE, or Hypalon and glands shall be PTEE or Neoprene.
- viii). Each pump shall be provided with inlet and outlet isolating valves and where necessary with pressure relief 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.
- ix). A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe may be shut off or where pressure may rise to an excessive point. the relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on the pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bounded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.

- x). Pump transferring/dosing chemicals to system under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release or air where necessary.
- xi). Unless otherwise specified flushing connection shall be provided at each 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.
- xii). Dosing Pumps and motor 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 provided with filling and drain connections and visible oil level indication.

1.3.24.1 Chemical Tank and Mixer

i). General

This tank shall be used to dissolve the alum or polymer to a constant concentration and feed the solution to the outlet channel of the aeration tank or the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, electrical level gauges, direct reading level gage, ladder, air exhaust pipe etc.

ii). Fabrication

- (a) The tank shall be made of corrosion resistant material.
- (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 angular 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.
- (g) Alum feed cage of stainless steel shall be provided inside the alum solution tank.

iii). Materials

- (a) Main Tank body : GRP/HPDE or equivalent

- (b) Mixer frame : SS316
- (c) Mixer shaft : SS316
- (d) Blade : SS316

iv). 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

1.3.24.2 Alum Dispersion Rapid Mixer

- i). The alum dispersion rapid mixer shall be in-channel submersible chemical vacuum induction unit and consist of chemical induction unit with mount bracket, guide rail assembly, floor mount base, boom hoist with manual brake winch and SS 316 cable, hose assembly, control panel and submersible power cable.
- ii). The unit shall be provided instantaneous diffusion / mixing and the highest level of durability and performance required for chemical feed application.
- iii). The hermetically sealed SS 316 motor shall provide the highest level of durability and performance required for chemical feed applications. All wetted materials shall be constructed from Grade 2 Titanium (unalloyed) and shall be designed for use with all common water and wastewater treatment chemicals. The mounting bracket shall be engineered for installing in open-channel applications.
- iv). The material of construction of chemical induction shall be as follows:

S. No.	Component	Material
(i)	Vacuum chamber	SS
(ii)	Vacuum port	SS
(iii)	Vacuum enhancer	<i>Non-metallic</i>
(iv)	Propeller	SS
(v)	Propeller bolt	SS
(vi)	Shaft	SS
(vii)	Mechanical seals	Carbon /ceramic
(viii)	Hardware	SS 316

1.4 Pipe work

1.4.1 Pipe work General

All sewage pipes inside the plant premises shall be made of DI internally lined with SFRC lining. The treated and chlorinated sewage should be disposed off to the disposal site by closed RCC pipes or DI pipe. In general, the colour code for piping shall be blue for portable water, white for air and red for gas as received colour from manufacturer for all other sewage pipes.

The pipe works for the plant involves procuring, supply, laying and jointing of suitable size electrically welded steel, CI, DI, uPVC, RCC and PSCC pipes along with matching specials etc. as required. All yard piping inside the plant shall be CI or DI. All pipe work and fittings shall be a class rating in excess of the maximum pressure attained in service including any surge pressure. The pipe work installation shall be so arranged to offer ease of dismantling and removal of pumps or major items or equipment. CI/DI piping above ground level shall be only flange jointed and adequately provided with structural/masonry supports.

SS AISI 316 expansion bellow which can take radial and axial misalignment of minimum one percent of the valve nominal size and tie bolts shall be provided. All pipe work shall be adequately supported with purpose-made fittings. When passing through walls, pipe work shall incorporate a puddle flange. flange adapters and union shall be fitted in pipe work runs, where necessary, to permit the simple disconnection of flanges, Valves and equipment.

The operator shall be responsible for ensuring that the internal surfaces of all pipe work are thoroughly cleaned before and during erection and commissioning. Cleaning shall include removal of dirt, rust, scale and welding slag due to site welding. Before dispatch from manufacturer's works, the ends of the pipe, branch pipes etc., shall be suitable removed until immediately prior to connections adjacent pipes, valves or pumps.

All mallbore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of owner's representative. all underground-buried mild steel piping unless found otherwise necessary, shall be protected by the application of hot coal tar enamel and fibreglass wrapping. The coating shall consist of one coal tar primer one coat, wrapping of fiber glass one more coat of enamel and the final wrap of enamel impregnated fiber glass.

All water supply plumbing pipeline shall be of uPVC class 4 thick-walled inside the premises in concealed piping. they shall be GI class B in external locations and either anchored externally with SS AISI fasteners or appropriately buried below the ground with a sand cushion of 20 cm all round. All sanitary piping shall be of uPVC class 4 suitably buried below the ground with a sand cushion of 20 cm all round. changes in direction on the ground shall be achieved with inspection chambers of 45 cm X 45 cm and heavy-duty CI/steel reinforced fiber glass chamber covers.

1.4.2 GI Pipes

The procurement, supplying, laying, jointing and testing at works and site of galvanized iron pipes and fittings shall be in accordance with IS 1239 (part I and II) and its latest revisions. The general requirements relating to the supply of mild steel tubes shall conform to IS 138. The sulphur and phosphorus requirements in steel shall not exceed 0.05 % each. The galvanizing of the pipes shall be as per IS 4736. the zinc coating shall be uniform adherent, reasonably smooth and free from imperfections.

The pipes shall be galvanized before screwing. all screwed pipes and sockets shall have pipe threads confirming to the requirements of IS 554. Gauging in accordance with IS 8999 shall be considered as an adequate test conformity of threads of IS 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

The specifications for G.I. pipes shall be generally in accordance with Standard specifications. the tolerances on the length shall follow IS 1239 -part I. The fitting for G.I. pipes shall be of mild steel tubular or wrought steel fitting conforming to IS 1239 Part II. The laying of GI pipes and fitting shall follow the relevant Is codes. These pipes shall be used for drinking water supply for the office and laboratory buildings. The pipes shall be painted with two coats of anticorrosive bit mastic paint.

1.4.2.1 Testing of G.I. Pipes

Hydrostatic test shall be carried out at works at a pressure of 5 Mpa, maintained for at least 3 sec. and shall not show any leakage in the pipe. The tensile strength of length of strip cut from selected tubes, when tested in accordance with IS 1894 shall be at least 320 N/mm². The elongation percentage shall be as per IS 1239 Part I. The bend test shall also be carried out as per IS 1239. The G.I. Pipes and fittings shall be tested at site after they are laid and jointed as per standard specifications.

1.2.1 Unplasticized Poly Vinyl Chloride (uPVC) Pipes

The latest versions of IS shall be adhered to for the design, manufacturing, inspection, factory testing, packing, handling and transportation, laying and jointing of the uPVC pipes. The rubbers shall be vulcanized from Ethylene Propylene (EPDM) confirming to IS 5382. The uPVC shall be of minimum 4 kg/cm² and as per IS 4985 and the pipes for plumbing work in office buildings shall be SWR (type B0 as per IS 13592, with electrometric sealing rubber ring joints. The method of sampling of rubber rings should be as per IS 5382.

The material from which the pipes are made shall consist substantially of unplasticized PVC as per IS 10151, to which only those additives shall be added that are absolutely needed to facilitate the manufacture of the polymer and the production of sound, durable pipes of good surface finish, mechanical strength and opacity. The total quantity of additives like

plasticizer, stabilizer, lubricants and fillers shall not exceed more than 7 %. The bulk density of uPVC pipes shall be 1.39 to 1.44 gm/cm³. The PVC resin suspension grade K-66/K-67 shall be used for extrusion of uPVC pipe. The uPVC fittings shall be fabricated from Class 4 uPVC as per IS 4985.

1.4.2.2 Tests on Material:

Following in house tests shall be carried out on the raw material:

- Grade (K-value)
- Particle size Distribution
- Bulk density of resin
- Bulk density of compound

1.4.2.3 Acceptance Test on Pipes:

The acceptance test shall be conducted in accordance with IS 4985 and presence of the Engineer's representative.

- Visual and dimensional Check
- Reversion test
- Vicat softening test
- Ash content
- Bulk density
- Resistance to external blows
- Internal Hydrostatic pressure test for pipes and joints
- Opacity

1.4.2.4 Marking on Pipes

Each pipe shall be clearly marked as indicated below:

- Manufacturer's name and trade mark
- outside dia in mm
- Class of the pipe and pressure rating
- Month and year of manufacturing
- Length of pipe
- Marking of insert depth of spigot

1.4.2.5 Marking on Rubber ring

Each sealing ring shall be permanently marked with:

- Manufacturer's name and trade mark
- Month and year of manufacturing
- Dia of pipe for which the ring is suitable
- Type of rubber material

1.4.2.6 Tests on Rubber Ring

Following tests shall be conducted on rubber rings conformity:

- Hardness
- Tensile strength
- Elongation at break
- Compression test
- Accelerated ageing
- Water absorption
- Stress relaxation

1.4.3 Ductile Iron (DI) Pipes

The Di pipes shall be centrifugally cast(spun) for water and sewage application and confirming to IS 8329-2000. The pipes used shall be both gasket joints and flanged joints. The minimum class of pipe to be used shall be class K-9 as per IS 8329. In general, pipes inside the buildings and below structures shall be jointed as double flanged pipes and those outside the building can either EPDM gasket as per IS 5382 and manufactured by the pipe manufacturer only.

The pipes shall be supplied in standard length of 5.5 m and 6.00 m length with suitably rounded chamfered ends. Any change in the stipulated length should be approved by the engineer's representative. The flanged joint shall be as per IS 8329. The pipe supply will also include one rubber gasket for each flange.

1.4.3.1 Inspection and testing

The pipes shall be subjected to following tests for acceptance:

- Visual and dimensional check as per IS 8329
- Mechanical tests as per IS 8329
- Hydrostatic tests as per IS 8329
- The test reports for the rubber gaskets shall be as per acceptance test of the Is 5382.
- Sampling shall be done as per IS 8329

1.4.3.2 Marking

All pipes shall be marked as per IS 8329 and as show in below:

- Manufacturer's name /stamp
- Nominal diameter
- Class reference
- A white ring line showing length of insertion at spigot end.

1.4.3.3 Packing and Transport

The pipes should be preferably transported by road from factory and stored as per the manufacturer's specifications to protect them from damage.

1.4.3.4 Specials for DI pipes

The DI specials shall be manufactured and tested as per IS 9523 or BS 4772. the mechanical test and hydrostatic test shall be as per IS 9523. The tolerances on the dimensions shall be as per Is 9523. The manufacturer of the pipes shall supply the fittings.

1.4.3.5 Supply

All the DI fittings shall be supplied with rubber rings for each socket. The rubber ring shall be as per IS 12820 and IS 5328. flanged fittings shall be supplied with one rubber gasket per flange and the required numbers of nuts and bolts.

1.4.4 Reinforced Cement Concrete (RCC) Pipes

1.4.4.1 Design

Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.

1.4.4.2 Manufacturing

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant clause of IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and collars/rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

The Engineer shall at all reasonable times have free access to the place where the pipes and collars/rubber rings are manufactured for the purpose of examining and testing the pipes and collars/ rubber rings and of witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot. The decision of the Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

1.4.4.3 Manufacturing

For all materials Factory's test result, and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the Engineer before carrying to sites.

1.4.4.3.1 Cement

Cement used for the manufacture of RCC pipes and collars shall conform to relevant IS codes. The use of pozzolana as an admixture to Portland cement shall not be permitted.

1.4.4.3.2 Aggregates

Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20mm, whichever is smaller.

1.4.4.3.3 Mixing and Curing Water

Water shall be clean, colour less and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. Contractor shall submit water quality report before using it.

1.4.4.4 Reinforcement

Reinforcement used for the manufacture of the RCC pipes and collars shall be mild steel Grade I or medium tensile steel bars conforming to IS:432 (Part-1) or hard-drawn steel wire conforming to IS: 432 (part-2). Reinforcement cages for pipes and collars shall be as per relevant requirement of IS:458.

1.4.4.4.1 Concrete

Concrete used for the manufacture of RCC pipes and collars shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of IS: 458. Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

1.4.4.4.2 Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

1.4.4.4.3 Dimensions

The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS:458 for different classes of pipes.

The tolerances regarding overall length, internal diameter of pipes or sockets and barrel wall thickness shall be as per relevant clause of IS: 458.

1.4.4.4.4 Workmanship and Finish

Pipes shall be straight and free from cracks. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between the Engineer and the manufacturer or supplier.

The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.

The pipes shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

The deviation from straight in any pipe throughout its effective length, tested by means of rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters 3 mm for every meter run.

1.4.4.5 Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458. Engineer reserve the right to attend all testing.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS:458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

- i) Hydrostatic test
- ii) Three edge bearing test
- iii) Absorption test
- iv) Visual Examination

1.4.4.5.1 Sampling

In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every pipe be selected till the requisite number is obtained, or being the integral part of N/n where N is the lot size and n is the sample size.

All pipes selected shall be inspected by Engineer for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.

All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

All result of tested data must be prepared by contractor at site so that the Engineer shall make decision of “fail or pass” at once. All cost for the test shall be borne by the Contractor.

1.4.4.5.2 Marking

The following information shall be clearly marked on each pipe:

- a) Internal and External diameter and length of pipe
- b) Class of pipe
- c) Date of manufacture and
- d) Name of manufacturer or his registered trade-mark or both.

1.4.4.6 Joining

1.4.4.6.1 General

Jointing of RCC pipes shall be done as per the requirements of following Employer's Requirements and as per the relevant IS standard. After jointing, extraneous material, if any, shall be removed from the inside of the pipe and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382. The pipe joint work must be done neatly and keep even slope and level for pipe laying works.

1.4.4.6.2 Spigot and Socket Joint

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar which shall be rammed with caulking tool. This joint is used for low pressure pipe line.

1.4.4.6.3 Collar Joint

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by the Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation.

The collar shall then be place symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand to withstand any stress and prevent any water leakage, tempered with just sufficient water to have a consistency of the semi-dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a fillet sloping at 45° to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

1.4.4.6.4 Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shaped to form a self-centring joint with an internal jointing space 13 mm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

1.4.4.6.5 Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

1.4.4.6.6 Spigot and Socket (Semi Flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar shall then be filled into the remaining annular space with a caulking tool.

1.4.4.6.7 Collar Joint (Semi-flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and collar, seals the joint. Stiff mixture of cement mortar shall then be filled to withstand stress and prevent any water leakage, into the remaining annular space and rammed with a caulking tool.

1.4.4.6.8 Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The RCC pipes shall be of spigot and socket type and rubber rings shall be used, and the manufacturer's instructions shall be deemed to form a part of these Employer's Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

1.4.4.7 Cleaning Of Pipes

As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by the Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

It shall also be ascertained by contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

1.4.4.8 Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour. The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of “fail or pass” at once. All cost for the inspection shall be borne by the Contractor.

1.5 Valves

1.5.1 Sluice Valves

Sluice valves shall be of 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 450 mm and above. The gap between the shoe and channel shall be limited to 1.5 mm.

Valves of 450 mm and above shall be provided with thrust bearing arrangement for ease of operation.

Valves of dia 450 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 as unbalanced head 15% in excess of the maximum specified rating. Valves 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.

The entire hand wheel shall be arranged to turn in a clockwise direction to close the valve. the direction of rotation of opening and closing of the valve shall be indicated on the hand wheels.

The material of construction of Valve shall be as follows:

Sr. No.	Component	Material
1	Body and Doors	CI IS 210 Gr. FG 260
2	Spindle	SS BS : 970 Gr 431
3	Seating rings	SS BS: 970 Gr 316
4	Back Seat Bush	Bronze IS:318 Gr LTB2
5	Shoe and channel linings	SS BS: 970 Gr 316

1.5.2 Knife Gate Valves

- i). The valve shall meet the requirements of MSS SP 81 / AWWA C520-10.
- ii). Outer body shall be provided with inner liner in corrosion resistant SS which shall extend into gland. The body shall be devoid of any wedge/dead pockets to avoid setting of suspended particles and solids in the service fluid. MOC & Design may be offered as per AWWA C 520-10 also.
- iii). 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 movements.
- iv). Seat shall be so designed that there is no recess / relieved groove to harbour 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.
- v). The stem shall have double start threads cut in order to ensure smooth and speedy operation.
- vi). Gland packing shall offer minimal frictional resistance and precludes external lubrication. As positive sealing element, the packing shall also include a resilient rubber ring.
- vii). 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 ensure the fluid contact with the seat ring minimal.
- viii). The material of construction of valve shall be as follows:

Sr. No.	Component	Material
1	Body	CI IS:210 Gr FG 260
2	Inner Lining	SS BS:970 Gr 316
3	Knife gate/plate	SS BS:970 Gr 316
4	Stem	SS BS:970 Gr 316
5	Seat ring/Boss	SS BS:970 Gr 316
6	Gland Housing	DI BS:2789 Gr 500
7	Gland Packing	Teflon Impregnated with the asbestos + rubber

1.5.3 Butterfly Valves

- i). This valves shall be installed at the pipe-line to seal the water or air and to adjust the flow/
- ii). Valves shall be used suitable for throttling operations and for infrequent operation after period of inactivity.
- iii). The body of the valve shall be made from cast iron of ductile iron.
- iv). Valves shall have fabricated steel, cast iron or ductile iron discs with a resilient rubber sealing ring.
- v). Valves stem, shall be if stainless steel designed for both torsion and shearing stresses when the valve is operated with permanently self-lubricated shaft stub bearing, sized to withstand bearing loads.
- vi). Butterfly valves shall be provided with hand-wheels and rack and pinion gearing operation. the valves shall be open by turning the hand wheel in an anticlockwise direction. the direction of valve opening and closing shall be marked on the hand wheel casing.
- vii). The valve shall be designed to hold the disc in any intermediate position between fully opened to fully closed without creeping or fluttering by manual or electrical operation.
- viii). The material of construction of valve shall be as follows:

Sr. No.	Component	Material
1	Body	CI IS 210 Gr. FG 260
2	Disc	CI IS 210 Gr. FG 260
3	Stem	SS 316
4	Seat	Rubber or Equivalent

1.5.4 Non Return Valves

- i). The internal parts of the valves shall be easily accessible for inspection through inspection hole.
- ii). Hydraulic passages and door shall be designed to avoid cavitations.
- iii). 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.

- iv). Valves shall be quick closing type with non-slam characteristics. In case of swing type , the nonslam characteristics shall be achieved by providing suitable combination of door and hydraulic passages without any external level/damping arrangement.
- v). Valves of 450 mm and above shall be provided with supporting foot
- vi). Swing door valves of size 600 mm and above shall be of multi door type.
- vii). Direction of the flow shall be clearly embossed on the valve body
- viii). Maximum pressure drop across the valve shall be 0.4 mm WC
- ix). Maximum allowable leakage rate shall be 7 cc/hr/mm diameter.
- x). The material of construction of valve shall be as follows

Sr. No.	Component	Material
1	Body & Door	CI IS 210 Gr. FG 260
2	Body and door Ring	SS ASTM A743 CF8, BS 970 Gr. 316 S11
3	Hinge Pin	SS BS 970 431 S49
4	Bearings	Teflon

1.5.5 Telescopic Valves

- i). The telescopic valve shall be a proprietary item of proven design manufactured in CI and adjustable to cater for 1000 mm variation in level.
- ii). The bell mouth height shall be controlled by a hand wheel operated from top of the chamber.
- iii). The bell-mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.
- iv). The ball mouth shall be connected by swept tees to a CI sludge outlet pipe of 300 mm diameter.
- v). Material of construction shall be as follows.

Sr. No.	Component	Material
1	Bell Mouth	CI IS : 210 Gr. FG 260
2	Piping	CI IS 210 Gr. FG 260

3	Spindle	SS 316
4	Hand Wheel	CI IS 210 Gr. FG 260

1.5.6 Pressure / Vacuum relief Valves

- i). Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a present maximum allowable pressure. the valves shall be drops tight under no flow conditions.
- ii). 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.
- iii). 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.
- iv). 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.
- v). Body ends shall be flanged and drilled to BS 4504.

1.3 Material Handling Equipments

Contractor shall supply, install, test, commission and maintain the material handling equipments which shall be required for normal operation and/or maintenance of the STP. the selection and sizing of the equipments shall be based on the requirements of the equipment to be maintain.

1.5.7 Electrically Operated Hoists

- i). Electrical 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, operator panel, all wiring, limit switches, etc.
- ii). Electric hoist shall confirm 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.
- iii). Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull.
- iv). Drums shall be machined grooved right and left with grooves of a proper shape for the rope used.

- v). 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
- vi). Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 37 wires per strand with minimum ultimate tensile strength of 1.6×10^6 kN/m².
- vii). 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.
- viii). 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. breaks shall apply when either the motor controller or the main power switch is in "OFF" position or in the event of power failure.
- ix). Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS: 325. Pendant control switch, controllers and resistor, controls, electrical protective devices, cable and conductors, earthing guards etc. shall be as per IS: 3938. limit switches shall be provided for over hoisting and over lowering.
- x). The electrical hoist shall be of class II duty.
- xi). 25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer's works.

1.5.8 Hand operated Hoist and Trolleys

- i). Manual hoist 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.
- ii). 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 as per IS 3109/BS 1663/BS 3114. The load wheel is to be made heavy duty malleable castings. the hand chain should be as per BS 6405 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 steel of heat treated alloy steel. strength, Quality of steel, heat treatment, face, pith of teeth and design shall be as per BS-436, BS-545 and BS 721. Spur and helical gear must comply with BS 436 and worm with BS 721. Bearing must be ball and roller type as per IS 2513 / BS 2525-32. Proper lubricating arrangements are to be provided for bearing and pinion. The brakes for the lifting gear shall be automatic and always in action.
- iii). 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 a way that is clearly visible from the operating level.

1.5.9 Manually Operated Travelling Crane

- i). The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. steel used shall be tested quality steel confirming to IS 2062. The girder shall have enough strength to carry the test load without causing undue stress or deflection.
- ii). The long travel bridge wheels shall be rim toughened, heat treated carbon steel or low alloy steel or CI. they shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The Wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied.

1.5.10 Trolley and chain Pulley Block

- i). The chain pulley block shall be operated on the lower flange of the bridge girder.
- ii). The load chain shall be made of alloy steel as per IS:3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.
- iii). The hand chain for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. the hand chain wheel shall be made from pressed sheet and shall be provided with roller type guarding to prevent snagging and fouling of the chain.
- iv). All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS : 4460.
- v). The trolley track wheels shall be rim toughened, heat treated carbon steel or low alloy steel or CI and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.
- vi). The travelling trolley shall be made of rolled steel as per IS : 2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. the two side plates shall be connected by means of an equalizing pin.
- vii). Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.
- viii). The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. they shall be single type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swivelling shall be provided. Hook shall be as per BS: 2903/IS:3815.
- ix). The break for the lifting gear shall be automatic and always in action. It shall be screw and friction disc type self actuating load pressure brake. Breaks shall offer no resistance during hoisting.
- x). Ratchet and pawl mechanism shall be provided to arrest the full load from lowering due to gravity. The ratchet and pawl shall be of steel, hardened and tempered so as to attain required wear resistance and toughness.

1.5.11 Jib Crane

Fixed jib crane shall be provided in for lowering/removal of equipments/parts to/from the reactor tanks floor and transferring the same outside reactor area. The crane capacity shall be 1.25 times the maximum weight to be handled or 1.5 tonnes, whichever is more.

The lift and reach of the crane shall be suitable for the equipments/parts to be handled. The crane shall be capable of being swivelled by 360 deg. All material used in the construction shall be corrosion resistant, MS used shall be galvanized. Rope chains and pulleys shall be of SS construction. Hardware shall be of SS 316. the jib crane shall also be provided for submersible pumps in reactor tank, thickened sludge sump.

1.5.12 EOT Crane

The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall conforming to BS 2573, IS : 3177 or relevant internationally approved standards.

The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as required along the full span length of the bridge girder. steel shall be tested quality as per ASTM A36 except that, plates more than 20 mm thick shall conform to IS 2062, BS 4360 or relevant international standards. The All antifriction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

Wheel base and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel shall be double flanged type. The wheel dia. and rail sizes shall be suitable for the wheel loads. The crane rail shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safety encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100 000 operating hours. electro-magnetic or hydraulic thrust breaks shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

Hook shall be solid forged, heat treated alloy or Carbon Steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS: 2903 / BS:3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook. Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 37 wires per strand with minimum ultimate tensile strength of 1.6×10^6 kN/m² of right hand Ordinary laid construction. The ropes shall have a 6 safety factor on the specified working load, and shall conform to IS: 2266. Rope drums shall be grooved and shall be either cast iron or cast steel or welded steel as per IS:3177, BS:466.

Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be forged carbon or heat treated alloy steel. Strength quality of steel, heat treatment, face, pitch of the teeth and design shall confirm to BS: 436, IS: 4460 and BS:721.

Name plate showing the capacity, year of manufacturing and rated capacity of the crane, in figure not less than 150 mm height shall be placed on the each side of the crane girder.

The deflection test shall be done as per IS:3177

All accessory and auxiliary electrical equipments including drive motor, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant, push button station, protective devices, operation devices, cables, conduits, etc, necessary for the safe and satisfactory operation of the crane shall be provided.

Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces. Pendant type button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:

- "start" and "stop"
- Long travel -'Right' and 'left'
- Cross travel 'To' and 'Fro'
- Hook 'Hoist' and 'Lower'
- Red indicating lamp for supply 'ON' indication.

Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent over travel for each of the following:

- for "UP" and "Down" motion of the hook

- Long travel motion
- Cross travel motion

Crane structures, motor frame and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor sets shall be provided with two studs for earthing.

All motors shall be of the quick reversing type with electrical mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the hook loaded. Facilities shall be provided for the accurate location of the hook by means of inching the cross travel and down shop travel motions.

Sufficient slings, ropes, shackles, lifting beams, etc. shall be supplied to handle all items of plant covered by the crane. they shall be labelled or marked with safe working load and the purpose for which they are intended.

The crane and all slings, ropes and other lifting equipments shall be tested by the manufacturer at their place. The test shall be carried out at 125% of safe working load and test certificate shall be supplied.

The operator shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail safe protection in the event of an power failure. All access ladders and platforms necessary to carry out maintenance and repair shall be provided and installed by the operator.

All electrical equipment shall be fully tropicalised

Site tests shall be carried out by the operator who shall supply the necessary materials for the test load. The test load shall be removed from site by the operator after successful tests have been carried out.

1.6 Auxiliary Equipments

1.6.1 Reduction Gear Units

Reduction gear units, wherever provided shall be double reduction units without V-belts and pulley, gear 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 be confirm to BS:436 and BS:721. split gears shall not be used. Gears and pinions shall be pressed on and keyed to shafts.

All pinions and gears are to be of the totally enclosed type up to the last stage of reduction in all motions and shall be carried in fabricated steel gear cases which must be dust-proof and firmly sealed to prevent oil leakages and shall be oil bath lubricated. The gear boxes shall have covers split horizontally and arranged so that top half can be removed for inspection. They shall be fitted with bolted type machined inspection covers and with cast steel cartridge housing for carrying roller bearings.

Dip sticks or indicator shall be provided for indicating the oil level. Guards shall be strong enough to retain the whole gear or any part that might otherwise fall. No overhanging gears shall be used. Drain plugs shall be provided on all gear cases. Lifting lugs shall be provided for handling purposing.

1.3.1 Propeller Exhaust Fan

The fan should comply with IS 2312.

The blades shall be of MS and properly balanced so as to avoid noise and vibration. The blade and Blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing damage to the fan or wall.

Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. moulded parts, if used, shall be such material as to withstand the maximum temperature attained in the adjacent component parts.

The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 mm² mesh bird screen. the sheet used for cowl should be 14 G.

1.6.2 Air Conditioning Equipment

Wall mounted split type air conditioners of appropriate capacity shall be provided for the control room. Outdoor condensing unit shall be located on the roof of the building or grouted on the external side of the wall with suitable brackets.

1.6.3 Domestic Water Pump Sets

The pump shall be Centrifugal type, self priming and mono-block type, suitable for pumping the clear water and treated sewage water. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non return valves on the discharge side shall be forged steel. Piping shall be as per IS:1239 heavy class.

1.6.4 Fire Extinguishers

- i). 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 more stringent.
- ii). All the extinguishers shall be of TAC approved.

1.7 Inspection and Testing

- i). Inspection of all the equipments shall be carried out by the manufacturer at their facility in the presence of purchaser or his representatives.
- ii). Successful bidder has to intimate purchaser / his representative in writing (Inspection call), 7 working days before the scheduled date of inspection.
- iii). All internal test reports (as per approved QAP/ contract Document) to be submitted along with the inspection call letter.

1.8 INDUCTION MOTOR

1.8.1 SCOPE

The specification covers the design, material, constructional features, manufacture, inspection and testing at the VENDOR's / his SUB-VENDOR'S works, delivery to site and performance testing of Low Voltage induction motors rated up to 1000V.

1.8.2 CODES AND STANDARDS

The design, material, construction, manufacture, inspection, testing and performance of induction motors shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the applicable standards specified in data sheet latest revision as on the date of offer. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility. In case of conflict between the standards and this specification, this specification shall govern.

1.8.3 DRIVEN EQUIPMENT

- a. When this specification forms part of the driven equipment specification, information not given in the Data Sheet will be governed by the driven equipment specification.
- b. Motors shall be capable of satisfactory operation for the application and duty as specified in the motor Data Sheet and as specified for the driven equipment.

1.8.4 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 as specified in Data Sheet.
- b. Supply Condition
 - i. Variation in supply voltage from rated voltage: $\pm 10\%$
 - ii. Variation in supply frequency from rated frequency: $+5\%$
 - iii. Combined voltage and Frequency variation: $+10\%$
- c. Motors shall be suitable for the method of starting specified in the Data Sheet.
- d. The minimum permissible voltage shall be 85% of the rated voltage during motor starting.
 - i. Motors shall be capable of starting and accelerating the load with the applicable method of starting, without winding temperatures reaching injurious levels, when the supply voltage is in the range of 85% of the rated motor voltage to maximum permissible voltage specified in Data Sheet.
- e. The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerances as per the applicable standard) unless otherwise specified. The locked rotor current of VFD controlled motor shall be within the limit of IS12615 / IEC.
- f. Motors shall be capable of developing the rated full load torque even if the supply voltage drops to 70% of the rated voltage. The pull out torque of the motor shall be at least 205% of full load torque.
- g. Motors when started with the driven equipment coupled shall be capable of withstanding at least two successive starts from cold conditions & one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.
- h. Motors shall be of Energy Efficient type. Category of Energy efficiency shall be as mentioned in data sheet.

1.8.5 INSULATION

- a. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate.

- b. Motors which are VFD controlled shall be inverter grade and shall be suitably derated to take care of reduced cooling at lower speeds.
- c. Insulation of VFD controlled Motors shall be designed to withstand a dv/dt of 0.1 micro sec rise from 10 % to 90 % of steady voltage and a maximum peak of 1600 volts as per NEMA standard MG1 Part 31.40.4.2 .
- d. The insulation shall be of double coat winding wires which having superior electric strength and thermal capability for VFD controlled motors.
- e. Winding shall be insulated as VPI (Vacuum Pressure Impregnation) of winding with suitable resin forces which eliminating voids for VFD controlled motors.

1.8.6 TEMPERATURE RISE

- a. The temperature rises shall not exceed the values given in IS 12802. Under extremes of supply condition (clause 4.1 above), the temperature rise shall not exceed the value indicated in IS by 10°C.
- b. For motors specified for outdoor installation heating due to direct exposure to solar radiation shall be considered.

1.8.7 CONSTRUCTIONAL FEATURES

- a. All windings shall be of Copper. The winding insulation shall be Non-hygroscopic, oil resistant and, flame resistant.
- b. Motors weighing more than 25 kg. shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
- c. Noise level and vibration limit should not exceed as specified in relevant IS / IEC.
- d. Submersed Motor (wherever applicable) shall have following specific constructional features:
 - i. Motor shall be Air Filled yet capable of Water immersion up to 20mwc for S1 duty. Motors with Oil or Water filled windings shall not be allowed. Motor's Rotor shall be of dual caged copper bar brazed type to ensure;
 - Long Corrosion free Service life (in presence of high moisture inevitable in submerged motors, Aluminum corrodes much faster than Copper),
 - Ease of Onsite Repairing &

- Beneficial Fly Wheel type Inertial effect (as compared to aluminum rotor, copper rotor is heavy) which reduces detrimental effects of water hammer
 - Better Motor Efficiency & Cooler Operating Temperature.
 - Motors rated $\leq 110\text{kW}$ may be supplied with Aluminum Die Cast Rotors but Dual Cage Copper Bar shall be preferred.
 - The Motor Rating should be higher of the two criteria i.e., 10% over Maximum pump shaft input at any point of the curve &/or 20% over pump shaft input @ duty point
- ii. Motor Cooling :
- To restrict the Dead Water Level (in case of Vertical Installation) in the Sump to 1m, Medium & Large sized pumps ($\geq 55\text{kW}$) should have a Cooling Jacket – i.e. motor cooling is accomplished by circulation of pumped water between the motor casing & the jacket shell.
 - In case the pumps are to be installed horizontally, the motor can be cooled just by water immersion i.e. no jacketing is required.
 - This jacket shell is fed by cold water from the pump casing & discharges its heated water back into the sump (in case of Wet Installation) or Pump casing (in case of Dry Installation) by integrally cast ducts. There should not be any pipes, hoses, etc for this circulation.
 - Alternatively Close Circuit cooling technology (using Glycol, etc) may also be offered.
- iii. Motor Protection:
- Thermal Overload Protectors (Bi Metallic Over Load Relays) should be embedded in each phase of the stator winding to detect overheating & trip the motor from the control panel in the event of the temperature exceeding the safe operating limit (above B temperature class).
 - To detect primary Mechanical Seal's Leakage a Moisture & Winding Sensor shall be provided in intermediately Oil Chamber (& not in the

Motor casing or elsewhere) – this shall detect water mixing in oil by mode of increased leakage current from the moisture sensor.

iv. Motors Cables:

- A watertight Cable Junction Box sealed from the motor shall be provided for the motor power and signalling cables.
- The cable shall be brought directly out of the submerged motor without joints, and shall be of sufficient length, minimum 10 m to be terminated in an IP 67 junction box (in the scope of electrical contractor) outside adjacent to the wet well & above the HFL. They shall be sized in accordance with the electricity utility regulations and BS 7671.
- It should have Power as well as Control Cables of Dual Sheathed EPRS / PVC Armoured type with Copper Core of required size. However the Cross Section of the cable be shall ample enough to ensure a Voltage Drop of not more than 2% at actual running conditions.

v. Stuffing Box / Oil Chamber:

- The pressurized entry of water into the motor (from the pump's volute casing) should be prevented by two separate mechanical seals mounted in a Tandem mode within an oil chamber.
- The Primary (Inboard) seal should be of Silicon Carbide or Tungsten Carbide faces to withstand erosive wear due to any silt particles. The Secondary (Outboard) seal should be of Carbon v/s Cast Chrome Molybdenum Steel or Silicon Carbide or Tungsten Carbide – i.e., Thermally Unstable materials like Alumina/ Aluminum Oxide shall not be allowed.

1.8.8 BEARINGS

- a. Unless otherwise specified in data sheet, motor bearings shall not be subjected to any external thrust load.
- b. Unless otherwise specified, motor bearings shall have an estimated life of at least 70,000 hrs.
- c. The bearings shall permit running of the motor in either direction of rotation.

- d. When forced oil lubrication or water cooling is required, prior approval from the purchaser shall be obtained.
- e. It shall be possible to lubricate the bearings without dismantling any part of the motor.
- f. VFD controlled Motors shall have their bearings insulated to prevent motor shaft currents from entering the bearing race.
- g. The bearings should be Permanently Greased with Premium Quality, High Temperature, Long Life Grease thereby obviating the need of re-lubrication for up to L10 life of the bearings.

1.8.9 TERMINAL BOX

- a. Terminal boxes shall have a degree of protection of atleast IP 55 for out door applicable.
- b. Unless otherwise approved, the terminal box shall be capable of being turned through 360o in steps of 90o.
- c. Terminals shall be of stud type & the terminal box shall be complete with necessary lugs, nuts, washers.
- d. When single core cables are to be used the gland plates shall be of non magnetic material.
- e. Sizes of terminal boxes and lugs shall be as given in Table-I, unless specified otherwise in data sheet.

1.8.10 TABLE-I

415 V MOTORS - SIZES OF CABLES, STUDS, TERMINAL LUGS & TERMINAL BOXES

(TO BE PROVIDED ON MOTORS BY VENDOR)

Sr. No.	Motor Rating (kW)	1100V Al Conductor, armoured PVC/XLPE Cable Cores mm ²
1.	Upto 3	3x4
2.	3.1 - 7.5	3x6
3.	7.6 - 15	3x16
4.	16 - 25	3x35
5.	26 - 40	3x70

6.	41 - 55	3x120
7.	56 - 70	3x185
8.	71 - 85	3x240
9.	86 - 110	3x400
10.	111 - 200	3Rx1Cx500

1.8.11 PAINT AND FINISH

All motor parts exposed directly to atmosphere shall be finished and painted to produce a neat and durable surface which would prevent rusting and corrosion. The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed and treated with one coat of primer and finished with two coats of grey enamel paint.

1.8.12 HEATING DURING IDLE PERIODS

Motors rated above 30 kW shall have space heaters suitable for 240V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

1.8.13 ACCESSORIES

- a. Two independent earthing points shall be provided on opposite sides of the motor, for bolted connection of the PURCHASER'S earthing conductors as specified in data sheet. These earthing points shall be in addition to earthing stud provided in the terminal box.
- b. Except when otherwise specified, the motors shall be provided with a bare shaft extension having a key slot and a key at the driving end.

1.8.14 TESTS

- a. 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.

- b. 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.

SECTION: III
TECHNICAL SPECIFICATIONS FOR ELECTRICAL WORKS

SECTION: III TECHNICAL SPECIFICATIONS FOR ELECTRICAL WORKS

1.1 SCOPE OF WORK:

- 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, assembly, erection, testing, installation, commissioning & performance demonstration and handing over along with all necessary spares of original ratings & specifications on Design, Build & Operate basis. Inland and overseas transit insurance, transport, testing at site shall be Contractor scope. Tender BOQ and drawings are for reference purpose only which is the minimum requirements; Contractor to ensure that design & equipments 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 electrical Single Line Diagram & other relevant details) for entire electrical systems including all items, systems such as equipments, power & control cables/ cabling system, lighting system, earthing, lightning protection, main & auxiliary power distribution, instruments, civil works required for completion of Works.
- Contractor shall take due care of the site Seismic conditions and altitude while design of all equipments/ components used in entire electrical & instrumentation systems covered in this specifications. 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 each document/ calculations of system which is included in scope to Purchaser/ Consultant for final review/ approval. All design documents/ calculations prepared by Contractor shall be with 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 and included in offer.
- Contractor shall be solely responsible for any shortages or damages in transit for his supply scope, handling and/ or in storage of any materials and erection of the equipment, supply of erection tools at site. Contractor shall ensure that it will not affect any activity or project schedule. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.
- Contractor shall identify activities and mile stones of the work forecasted for next month with optimistic and pessimistic dates of work completion. Contractor shall prepare program evaluation and review techniques to identify critical path of project and activity sequences. The project schedule shall be prepared and updated fortnightly in MS Project.
- Nothing in this specification shall be constructed to relieve the Contractor of his/ her responsibilities towards following best engineering practices established in the country.
- All - Obtaining approval including load sanction / release from Himachal Pradesh Power Transmission Corporation Limited / Himachal Pradesh State Electricity Board (HPSEB), No Objection Certificates from HPPTCL / HPSEB, Electrical Inspector, relevant government agencies, statutory authority, as applicable is included in Contractor's scope.
- All necessary legal fees required for various applications to HPPTCL/ Himachal Pradesh State Electricity Board (HPSEB) / Electrical Inspector, relevant government agencies, statutory authorities shall be paid by the Purchaser. The HPPTCL deposit required to be paid for Load Release shall also be borne by the Purchaser.
- Contractor scope shall also include the selection of incoming voltage level as per HPPTCL/HPSEB norms and design, supply the equipments accordingly. However the incoming voltage available at Ashwini Khad STP is 22kV. The contractor had to check and confirm the same.

-
- The Contractor's scope shall also include measurement of soil resistivity at site by Wenner's four electrode method as per IS: 3043 – 1987 at minimum four locations at site. The earthing shall be designed for the actual mean soil resistivity value obtained.
 - 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 system and facilitate proper operation and easy maintenance of the plant. Any and all other works not indicated above but necessary/ required to complete the job in all aspects, are included in the Contractor's scope.
 - The Contractor shall include start up spares, essential spares, recommended spares and a set of special tools necessary for operation, routine maintenance of equipment supplied for a period of five years.
 - Whether specifically called for or not, all accessories required for normal and satisfactory operation (as deemed by the Purchaser) of the equipment shall be considered to be a part of the Contractor's basic scope of supply and/ or work and no claims whatsoever, for extra payment on these grounds, will be accepted.
 - Contractor should visit site and get himself/ herself ascertained regarding the scope of work for the complete Electrical & Instrumentation works before submission of quote/ offer.
 - Contractor's scope shall include design, engineering, manufacture, supply, testing, commissioning and handover of following electrical equipments/ systems as per tender specifications.
 - Tariff metering equipment & electric supply connection shall be provided by HPPTCL / HPSEB for which necessary liaison shall be done by Contractor.
 - Two/ four pole structure (along with necessary earthing, fence and gate) with GOD (including operating handle and lock), 9 kV Lightning Arrestors and Drop Out Fuses (wherever applicable for transformer(s) being fed directly from Two/ Four pole structure) for the HT power supply obtained through incoming transmission line/ cable.
 - Supply of breaker panel / Ring main Units (if installed capacity of transformer exceeds 500 kVA / as per statutory requirement) outdoor type.
-

- Distribution Transformer Oil type, ONAN, Dyn11, with OCTC/ OLTC + RTCC, AVR, Marshalling box.
- HV switchgears Panel metal enclosed indoor type with vacuum circuit breakers fully draw out including necessary control, metering & relaying devices.
- 415V LV metal enclosed switchgears including Power and Motor Control Centre (PMCC) including starter feeders, equipments (as per electrical SLD & technical specification requirements), PDBs, Sub DBs, Lighting DBs, Receptacles for utilities. Local Start/ Stop push button stations shall be provided near those motors which are not controlled from a local console/ panel.
- 415V LV capacitor banks with control panel consisting of automatic power factor correction (APFC) relay to improve the plant power factor up to 0.99. APFC panels shall be provided on both bus sections of the PCC/ MCC.
- Cabling system shall consists of various HT cable / LT cable of 1.1 kV grade, XLPE/ PVC insulated, multi-stranded Al/ Cu, GI round wire/ flat strip armoured power, control & instrumentation cables, GI ladder/ perforated type Cable Trays & associated accessories including support structures.
- Non Segregated Bus Duct where applicable if transformers rating is ≥ 1000 kVA.
- Provision for Continuous Monitoring of Electrical Power & Energy Parameters like Voltage, Current, Power Factor, Frequency, Kilo Watts, Kilowatt-hours etc.
- Earthing for HV / LV equipments and lightning protection system for all buildings in the Intake well, Pumping stations & all the locations. The general design shall be on the basis of following codes and standards (their latest amendments) in line with design criteria & specification requirements.
 - a) IS 3043-2007 : 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

- Lighting system for all indoor & outdoor areas of Pumping stations. The lighting system will be controlled by lighting panels installed in respective plant/ station areas, which will be fed from the main lighting DB.
 - Diesel Standby Generator
 - Variable Frequency Drives.
 - DC System:
 - a) 24/ 30V or 110V DC in built DC power pack unit shall be provided wherever HT switch gear panel is envisaged.
 - b) 110V DC Battery & Battery Charger (with inbuilt DCDB) shall also be provided wherever applicable
 - Submission of drawings & documentation as specified under “General Technical & Particular Requirement” section for Electrical equipments.
- Contractor’s scope shall also include all civil works required for electrical & instrumentation equipment/ structure such as equipment foundations, indoor & outdoor trenches, equipment support structures, two pole structures, flow meter chamber, control rooms, all excavation works including those for earthing, cabling etc, de-tanking area, soak pits, burnt oil pits, chamber etc.
- It is not the intent to completely specify all details of design and construction herein. Nevertheless, the Electrical, Instrumentation & Control system shall conform to high standard of engineering, design and workmanship in all respects and shall be capable of performing satisfactorily in continuous commercial operation under the specified environmental conditions.
- Purchaser reserves the right to issue addendum to the technical specification to indicate modification/ changes in the requirements, if so required at a later date.

1.2 PROJECT INFORMATION:

1.2.1 Site/ Environmental Conditions:

- Ambient temperature : 50°C.(site specific)
- Relative Humidity : 95%
- Area Classification : Non Hazardous / Hazardous
- Seismic Data : As per IS 1893 latest issue

- Altitude : 2276 m

1.2.2 General Design Criteria

- 22 Kv HT System

Nominal Voltage	:	22
Frequency	:	50 Hz \pm 5 %
No. of Phases	:	3
Connection	:	3 Wires
Maximum fault level	:	26kA for 1 sec

- 11 Kv HT System

Nominal Voltage	:	11Kv
Frequency	:	50 Hz \pm 5 %
No. of Phases	:	3
Connection	:	3 Wires
Maximum fault level	:	26kA for 1 sec

- LT System

Nominal Voltage	:	415 V \pm 10 %
Frequency	:	50 Hz \pm 5 %
Connection	:	4 wire
No load transformer voltage	:	433 V
System earthing	:	Solidly earthed
Maximum fault level	:	Based on the transformer rating

- AC Control , Lighting and Space Heating

Nominal Voltage	:	240 V \pm 10 %
Phase	:	Single
Frequency	:	50 Hz \pm 5 %
Connection	:	2 wire (Ph + N)

1.3 DESIGN CRITERIA FOR ELECTRICAL EQUIPMENTS/ SYSTEMS:

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3.1	General
3.2	Site/ Environmental Conditions For Equipment Design
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3.6	Busbar Sizing
3.7	Power Factor Improvement
3.8	Cable Sizing
3.9	Illumination System

1.3.1 General:

The design criteria, given below has to be followed by the contractor for designing/ sizing of electrical equipments covered under Contractor's battery limits; However it is to be noted by the Contractor that, following this design criteria does not relieve the Contractor from adherence to the standards, regulatory requirements & best engineering practices.

1.3.2 Site/ Environmental Conditions For Equipment Design:

- a) Ambient temperature : 50°C.

-
- | | | | |
|----|---------------------|---|-----------------------------|
| b) | Relative Humidity | : | 5 - 95% |
| c) | Area Classification | : | Non Hazardous |
| d) | Seismic Data | : | As per IS 1893 latest issue |

1.3.3 Estimation of Load/ Max Demand:

The following considerations are to be followed to arrive at the maximum electrical demand.

1.3.3.1 Load Factor

- | | | | |
|----|--|---|-----|
| a) | Main motors | : | 0.9 |
| b) | Auxiliary load (valve actuators, Crane/ Hoist, etc.) | : | 0.4 |
| c) | Lighting load | : | 1.0 |

1.3.3.2 Diversity Factor

- | | | | |
|----|--|---|-----|
| a) | Main motors | : | 1.0 |
| b) | Auxiliary load (valve actuators, Crane/ Hoist, etc.) | : | 1.1 |
| c) | Lighting load | : | 1.1 |

1.3.3.3 Power factor of Motors

- | | |
|----|--------------------------------------|
| a) | As per the Manufacturer's Datasheets |
|----|--------------------------------------|

1.3.3.4 Efficiency of Motors

- | | |
|----|--------------------------------------|
| a) | As per the Manufacturer's Datasheets |
|----|--------------------------------------|

1.3.4 Transformer Sizing/ selection:

1.3.4.1 Criteria 1:

- | | |
|----|--|
| a) | The capacity of the transformers will be calculated based on the total simultaneous maximum demand (calculated based on the load factors and diversity given above, PF, efficiency). |
| b) | Additional 10% contingency shall be considered for deriving transformer sizing. |
| c) | Similarly, after consideration of 10% contingency over maximum demand (MD), sizing of the selected transformer shall be such that maximum transformer loading shall not exceed 80% (of the MD + 10% Contingency) load. |

1.3.4.2 Criteria 2

- a) The adequacy of transformer sizing shall also be proved on the basis of % Voltage dip observed at the motor terminal. % voltage dip at motor terminal shall not exceed 15% i.e. with the use of appropriate starter & considering largest motor starting & base load (all other loads except the highest rating motor are running); the % voltage dip during starting at motor terminal shall not exceed 15%.
- b) The Voltage dip and fault level calculations needs to be calculated based on following actual data collected from nearest Substation and Grid.
 - i. The fault level of HT bus from which power supply will be taken to the plant.
 - ii. Impedance of HT Overhead Line Conductor/ HT Cable interconnecting the HT bus of Substation and HT switchboards of the Plant
- c) For the per unit calculation purpose, minimum starting current for various types of starter applications shall be considered as following:
 - i. DOL Starter - 6 times the rated current.
 - ii. Star- Delta Starter - 3 times the rated current.
 - iii. Variable frequency drive - 2.5 times the rated current
 - iv. Soft Starter - 3 times the rated current.

Wherever HT supply, above 100kVA is envisaged, 100% stand-by shall be provided for transformers. All the associated equipments/ accessories shall be provided for Stand-by transformer as well. In normal condition, the working transformers shall feed the entire bus sections & in case of failure of the working transformer, the stand by transformer shall fed the entire bus. In case of failure of both transformers, the DG shall fed the load of the entire bus.

The Load Losses and No-load losses of transformer shall be within the values given in IS 1180-2014.

1.3.5 Switchgear Sizing/ Selection

Switchgear shall be sized/ selected considering the following:

- Rating suitable for carrying full load current of the equipment.
- Suitability for Short Circuit Rating for 1 sec duration.
- Switchgear for motors shall be suitable for motor duty application.
- Switchgear for all the motor feeders shall be Type-2 co-ordinated. Motor starter selection shall be done as follows:
 - a) Direct On Line (DOL) Starter – For motors rated up to 5.5 kW
 - b) Star- Delta Starter - For motors rated above 5.5 kW to 75 kW
 - c) Soft Starter – For all Low/ medium voltage motors above 75 kW rating.
 - d) In-panel de-rating of minimum 20% or as provided in Manufacturer's catalogue, whichever is higher shall be considered.

1.3.6 Bus Bar Sizing:

The Contractor shall furnish calculations after award of contract, establishing the adequacy of the bus bar sizes to meet the continuous and short time current ratings as calculated.

The bus-bars shall be sized considering the following criteria:

- a) Sleeving made of insulating material on all bus bars.
- b) Design ambient temperature 50 Deg C.
- c) Final temperature of the bus-bars complying with requirements of IS 8623 & IEC 60947. Reduced temperature rise limit by 5K (for indoor panels) & 10K (for outdoor panels) to that of mentioned in IS 8623 & IEC 60947 shall be considered to satisfy the final temperature.
- d) Bus bars being inside the panel; De- rating for enclosure and ventilation.
- e) Bus bar suitability for carrying rated current continuously.
- f) Configuration of bus bars and Proximity effect
- g) Bus bars shall withstand the short time rating of the panel for 1 sec duration.

1.3.7 Power Factor Improvement

APFC Panel shall be sized considering following design criteria:

Total Capacity & Capacitor bank sizes shall be as given in Table below:

Capacity	5 kVAr	10 kVAr	15 kVAr	25 kVAr	50 kVAr	100 kVAr
* kVAr	# Nos.	# Nos.	# Nos.	# Nos.	# Nos.	# Nos.

* = Contractor has to calculate the capacitor rating based on the system power factor (0.85 or actual, whichever is lesser- to be corrected for 0.99. Rating of APFC panel shall be based on 50% of running load on each bus section & not on the connected load basis. Number of stages / steps in a particular APFC panel shall be decided by the Contractor such that minimum 8 steps & maximum 16 steps shall be provided in a particular panel. Minimum 2 steps in an APFC relay shall be kept as spare & thus minimum 10 steps APFC relay shall be considered.

Capacitor shall be All Poly Propylene (APP), double layer type.

Fixed type capacitor bank, with manual/ auto switching & components as indicated in reference electrical Single Line Diagram shall be provided in each Main incomer (LV) panel for transformer no load compensation.

For each bus section of the Main PCC/ MCC panel, separate APFC panel- based on above design criteria to be provided.

Other requirements of APFC panel & its components shall be as per requirement provided in this specification.

1.3.8 Cable Sizing

The Contractor shall ensure that cable and wires associated with the power distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use. Following main aspects shall also be considered while deciding the final size of the cables-

Supply voltage and frequency

All cables shall be selected to carry the corresponding full load current under site conditions.

Route length and disposition of cables

Maximum allowable temperature rise under normal full load condition based on the material of cable insulation (XLPE/ PVC).

Maximum short circuit current duration (fault clearing time) and final temperature of cable during short circuit current flowing through the cable.

For Cables emerging from ACB outgoing, fault clearing time shall be considered as 0.16 second (for Tie feeders, if any, it shall be 0.5 second)

For Cables emerging from MCCB outgoing, fault clearing time shall be considered as 0.1 second

For the HT incomer cables (metering kiosk to GOD, GOD to HT switchgear/ transformer) minimum fault clearing time shall be considered as 1 sec.

For cable from HT panel outgoing to transformer, fault clearing time shall be considered as 0.16 second.

Cable from transformer secondary to PCC incomer, fault clearing time shall be 1sec

Contractor to note that, the above fault clearing times are minimum to be considered & fault clearing time shall be considered as per actual relay co-ordination study.

Appropriate de-rating factors as per cable manufacturer's catalogue and enlisted below shall be considered for sizing the cable:

- a) Ambient Air Temperature (minimum 50° C).
- b) Ambient ground temperature (minimum 40° C to be considered)
- c) Laid in Air / ducts/ directly in ground etc.
- d) Depth of cable burial (minimum 750 mm for LT and 900 mm 11kV HT)
- e) Thermal Resistivity of Soil (minimum 150°C Cm/ W to be considered)
- f) No. of cables in a group-touching each other or separated by a distance
- g) No. of cable trays in tier
- h) Any other de-ration factors as applicable & as per Manufacturer's catalog.

Permissible voltage dips at the time of starting the corresponding motor/ load. Contractor to ensure adherence to the Criteria-2 mentioned above.

In running condition, cumulative voltage drop (at 100% rated load) shall not exceed 5% (measured at load end) for the LV loads.

All the HT cables shall be earthed (E) grade, multi-stranded Al conductor, XLPE insulated, inner/outer extruded PVC sheath ST2, galvanized steel flat strip armoured cables.

The 415V cables shall be 1.1 kV grade, multi-stranded Copper/ Al conductor, XLPE insulated, colour coded, inner and outer extruded PVC sheathed, galvanized steel round wire/ flat strip armoured cables.

Cables up to & including 6.0 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured & balance cables shall be Al multi-stranded conductor with galvanized steel round wire/ flat strip armoured.

Single core cable shall have non magnetic material armouring.

Control cables shall be Cu multi-stranded conductor with galvanized steel round wire/ flat strip armoured. For cables above 7 cores, minimum two spare cores shall be considered.

1.3.9 Illumination System

Illumination for various indoor & outdoor areas shall be conforming to the requirements mentioned below:

The illumination levels to be considered for the design of lighting system for various areas shall be as following. These are the illumination levels achieved at Work plane. Work plane height shall be considered as 0.76 m from FGL.

Area	Illumination Level (Lux) - Average values
Office rooms	300 Lux
Switchgear rooms	250 Lux
Control rooms	300 Lux
Chemical and general stores	150 Lux

Chemical plant room	200 Lux
All other indoor areas	150 Lux
Outdoor platforms and walk ways	50 Lux
Outdoor plant areas	20 lux
Switchyard & Transformer Area	
- General	10 Lux
- On Equipment	30 Lux
Roads	15 Lux
	16

- Critical Lighting shall be designed such that at all junctions, exit passages & strategic locations the Lux level shall be maintained above 10 Lux. Installite fixtures with built in battery backup shall be considered.
- Lighting design shall be performed using DiaLux Software Version 4.5 or its latest version / Original Equipment Manufacturer (OEM) validated software. The Validation Report along with software and data files shall be acceptable to Purchaser/ Purchaser's representative.
- Various design factors shall be considered as following :
 - a) Incoming supply Maintenance Factor:
 - i. Outdoor area : 0.6 (0.7 for LED)
 - ii. Indoor areas : 0.7 (0.8 for LED)
 - b) Reflectance Factors:
 - i. Wall : 30%
 - ii. Ceiling : 10%
 - iii. Floor : 30%

- c) Uniformity (Min./ Avg.) : 50% Minimum for indoor and 30% for outdoor

1.3.10 Earthing & Lightning Protection System:

The safety earthing and lightning protection system will be generally on the basis of following codes and standards (including their latest editions).

- a) IS 3043 -1987; Code of practice for Safety Earthing.
- b) IEEE 80 - 2000.
- c) IS/IEC 62305: Code of Practice for the protection of buildings and allied structures against lightning.
- d) CEA guidelines - 2010

The fault levels considered shall be as follows:

System	Fault level in kA
a) 22 kV System	26 kA for 1 sec
b) 11 kV System	26 kA for 1 sec
c) 415V System	* (50 kA) for 1 sec

(*) Contractor to design on the basis of actual impedance & adequacy calculations for sufficiency of earth conductor size shall be provided.

Following factors shall be considered for sizing the earthing conductor:

- a) Design Ambient Temperature : 50°C
- b) Allowable temperature rise for steel welded joints : 500°C
- c) Fault clearing time : 1 Second
- d) Overall earthing resistance : ≤ 1 Ohms

Measurement of soil resistivity shall be done using Wenner's 4 electrode method as described in IS 3043 -1987 including its latest amendment.

The soil resistivity of the plant area has not yet been measured, the same should be carried out during detailed engineering by successful Contractor.

After soil resistivity measurement; length of conductor, no. of earth electrodes and number of test pits shall be finalized based on this design criteria & the requirements specified in earthing requirements.

1.4 GENERAL TECHNICAL & PARTICULAR REQUIREMENTS FOR ELECTRICAL EQUIPMENT/ SYSTEMS:

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Sr. No.	Description
4.1	Tariff Metering Equipment.
4.2	Two/ Four Pole Structure arrangement inside plant premises including 11 KV point of supply breaker if required as per statutory norms
4.3	HT Metal Enclosed Switchgears
4.4	Distribution Transformers
4.5	415V Low Voltage Metal Enclosed Switchgears
4.6	Local Push Button Stations
4.7	APFC Panel with Capacitor Bank
4.8	DC System
4.9	Cabling System
4.10	Earthing & Lightning protection system
4.11	Lighting & Receptacle System
4.12	Diesel standby generator

1.4.1 Tariff Metering Equipment:

Tariff Metering equipment including combined CT/PT metering unit as per HPPTCL/HPSEB standards & specifications shall be provided by HPPTCL/HPSEB However, Contractor will have to do all liaisoning work for obtaining approval including load sanction/ release from HPPTCL, No Objection Certificates from HPSEB, Electrical Inspector (CEIG), relevant government agencies, statutory authority, as applicable is included in Contractor's scope.

1.4.2 11KV TWO/ FOUR POLE STRUCTURE :

The design, material, construction, manufacture and testing of two/ four pole structures shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards.

Two/ four pole structures shall conform to the latest applicable standards specified as under. In case of conflict between the standards and this specification, this specification shall govern.

Two/ four pole structures shall be erected in switchyard to receive HT power supply from power supply authority.

Each two/ four pole structure shall be inclusive of items listed below.

1.4.2.1 Structure:

- a) A two/ four pole structure shall be of a rolled steel joist of minimum ISMB 150 (150mm x 75mm) for 6 meter pole / ISMB 175 (175 mm x 90 mm) for 9/ 11meter pole with 400 mm x 400 mm x 8 mm thick base plate welded at bottom end of all the poles of structure.
- b) Mild steel cross members of minimum ISMC 100 mm x 50 mm x 6 mm size channels of 3.5 mtr in length, 8 Nos. shall be provided with cross bracing angles of minimum ISA 50 mm x 50 mm x 6 mm size of 4.5 meter in length.
- c) Side clamps, stay clamps, cleats etc. shall be fabricated from minimum 50 mm x 6 mm size MS flats as per actual requirements. All bolts, nuts, washers, etc. shall be of minimum 15 mm size.
- d) All the members of two/ four pole structure should be galvanized.
- e) Excavation of pits even in hard soil shall be done up to a depth of about 1/ 6 the length of pole and refilling the same after erection of structure and concreting work. Compacting the bottom of pits, providing cement concrete to suit at bottom and side of poles up to at-least 150 mm above FGL curing and making it hard as per requirement.
- f) Erection of RSJ poles and fixing of all structural members as per requirement shall be in line, level and properly facing the incoming and outgoing lines. Cross members shall be firmly tightened.

- g) All members shall be fabricated to suit mounting/ fixing of Gang Operated Disconnectors/ Isolators, Lightning Arrestors, Pin/ Post insulators, cable end termination Kit/ Box etc.
- h) All MS parts shall be painted with two coats of red oxide and two coats of aluminum paints.
- i) Earthing terminals shall be provided by welding 15 mm size bolts or cleats of 50 mm x 6 mm size MS flat shall be welded in each joist with a hole of 15 mm size and galvanized nuts, bolts, washers shall be provided as earthing terminals.
- j) Necessary hardware as required for completeness shall be supplied and erected.
- k) All drawings / documents such as GA drawing of two/ four pole structure showing all equipment mounted on the structure, technical particulars & Bill of Material etc shall be prepared and submitted to Purchaser/ Purchaser's representative for approval. Obtaining the approval from CEIG/ IMPD (GOG) and getting power released from supply authority are also included in the scope of work.

1.4.2.2 Gang Operated Offload Disconnectors (GOD) with Earth Switch:

- a) The double break type isolator (GOD) shall be manually operated and suitable for the specified site conditions and shall be able to-
 - i. Carry rated current without excessive temperature rise.
 - ii. Withstand the short circuit forces developed during fault.
 - iii. Carry the inrush current of the transformer.
 - iv. Interrupt small inductive and capacitive currents.
- b) The operating rod shall be extended up to the operating level and shall have a handle with 'lock and key' arrangement. The operating handle shall be at a level of 1.0 meter from finished ground level.
- c) The operating handles shall be mounted on the base of supporting structure. Guide bearings shall be provided if necessary at appropriate height above ground level. Necessary accessories viz. brackets, angles, guides, guide bearings for attaching the operating mechanism and operating handles to the structure and part of the isolator, rust proof pins, ball or roller type bearings shall be provided and installed.

All bearings shall be protected by means of covers and grease retainers. Bearings pressure shall be kept low to ensure long life and ease of operation.

- d) The operating mechanism design shall be such that, as soon as the moving blades reach the sparking distance during operation of isolator, springs shall take over to give a quick snap action closing so that the isolator closing is independent of manual effort. Similarly the springs must assist during opening operation to give quick breaking feature.
- e) All copper parts shall be Silver or Tin plated. All ferrous parts shall be hot dipped galvanized to assure long protection against tropicalized weather.
- f) The contacts shall be of silver faced copper ensuring sufficient contact pressure. The male and female contacts shall be of self aligning type to ensure trouble free operation during opening and closing of isolator. Mild steel arcing horn capable of breaking the magnetizing current shall be provided. Earth mesh below GOD to be provided

1.4.2.3 Isolator Mechanical Interlock:

- a) Electrical interlock arrangement shall be provided among double break bus isolator (GOD) and respective HT indoor type breakers.
- b) Interlocking arrangement shall be robust, heavy-duty type and sturdy in construction.
- c) Mechanical interlock between isolator & Earth switch shall be provided.

1.4.2.4 Insulators:

- a) Insulator shall be properly glazed with smooth surface without cracks etc. and dielectric property shall be properly co-ordinated with isolator voltage class. Porcelain used for the manufacturer of insulator shall be uniform, brown color, free from blisters, burns and other similar defects. Insulators of the same rating and type shall be interchangeable.
- b) Porcelain and metal parts shall be assembled in such a manner that any thermal expansion differential between the metal and porcelain parts throughout the range of the temperature variation shall not loosen the parts or create undue internal stresses which may affect the electrical or mechanical strength and rigidity. Each cap and base shall be of high grade cast steel or malleable steel casting and they

shall be machine faced and smoothly galvanized. The cap and base of the insulators shall be interchangeable with each other.

1.4.2.5 ACSR Conductor:

- a) Aluminum conductor steel reinforced shall be hard drawn from 99.5% pure electrolytic aluminum rods. The Contractor shall specify the conductivity.
- b) Chemical composition of the material shall comply with the requirements of relevant standards.
- c) The surface of conductor shall be clean and dry and free from any excess grease that may be used in its fabrication. The surface strands shall be smooth and free from burrs and other projections which may be a cause for increasing corona losses.
- d) The Contractor shall provide necessary treatment for the bus conductor to make it free from corrosion.
- e) The steel wire strand of conductor and steel conductor shall be hot dip galvanized. Zinc coating shall be evenly and uniformly for heavily coated wires.
- f) The steel core and inner layer of aluminum wires where more than one aluminum layer exist shall be protected with special grease in order to provide additional protection against corrosion due to salinity. The grease shall fill the whole space between wires within circumscribed cylinder at inner aluminum layer or at steel core if the conductor has only one aluminum layer.
- g) The grease shall be chemically neutral with respect to aluminum, zinc and steel. It shall withstand weather conditions given elsewhere and temperature of 85 degree centigrade without alternation of its properties.
- h) Bare conductor shall be covered in Alkathene pipes of suitable insulation to avoid accidental contact.

1.4.2.6 Drop Out (DO) Fuse Unit:

- a) Drop Out Fuse shall be of approved make suitable for incoming supply and shall be mounted on two pole structure complete with 3 fuse elements of required ampere suitable for continuous current rating and shall offer protection against fault level of suitable ampere.

b) The fuse link shall consists of iron channel base to stack insulators per phase, fuse carrier Bakelite tube, heavy duty non-ferrous metal parts and spring loaded phosphor bronze contacts.

c) The insulator shall comply with impulse voltage in accordance with relevant IS.

1.4.2.7 Station Class Lightning Arrestors:

a) The design, material, construction, manufacture, inspection and testing of lightning arresters shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.

b) In case of conflict between the standards and this specification, this specification shall govern.

c) The equipment covered in this specification shall conform to the latest edition of the following standards.

IS: 3070 (Part-3)	Lightning arresters for AC system – Specification (Metal Oxide Lightning Arrester without Gaps)
IEC: 60099-4	Metal Oxide surge arresters without gaps for AC system

d) Constructional Features:

- i. Lightning arrester shall be station class heavy duty and non- linear resistance type. The elements shall be in hollow cylindrical form, stacked together. Lightning arrestor shall be of class II, having non – linear voltage – current characteristic and having high discharge capability.
- ii. The entire arrester unit shall be housed in a porcelain insulating casing of high strength, made from brown glazed wet process porcelain, with metallic cover plates and terminal assemblies. The end castings shall be hermetically sealed and leak tested to protect the unit from moisture or breathing.
- iii. Pressure relief diaphragm, vent pipe, etc. shall be provided on the LA for the escape of gases formed. In the event of failure of L.A., the pressure relief directional aperture should be directed away from adjacent apparatus to prevent damage, due to arc transfer.

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- iv. All hardware such as clamps, screws, bolts, nuts, washers etc. shall be electro galvanized.

e) Insulators:

- i. The porcelain insulators used shall be made from wet process, and shall be homogenous, free from lamination, cavities and other flaws, which may impair its mechanical or dielectric strength. They shall be thoroughly vitrified, tough and impervious to moisture.
- ii. The glazing of porcelain shall be uniform brown colour, free from blisters, burns, cracks and other defects. The glazing shall cover all the porcelain part of the insulators except that area which serves as support during firing or are unglazed for the purpose of assembly.
- iii. The minimum creepage distance shall be as stipulated in data sheets. The petticoats shall be spaced for natural cleaning action by wind and rain and avoid concentrated hot spots where local stress can precipitate flashover.
- iv. All live metallic parts shall be suitably painted. All joints shall be fluid – tight and air tight. The design of insulators shall be such, as to produce uniform compression pressure joints.
- v. All insulators of identical rating shall be interchangeable.
- vi. Each bushing shall be provided with aluminum/ bimetallic terminal connectors suitable for inter – connection with aluminum tubular Bus bars or ACSR conductor as specified in data sheet.

f) Accessories: Each lightning arrester shall be furnished complete with the accessories as listed below:

- i. Anti - contamination and pressure relief diaphragm complete with vent pipe.
- ii. Two (2) grounding pads.
- iii. Base plate suitable for mounting on G.I. / steel structure or concrete structure.
- iv. Line side terminal suitable for specified conductor.

- v. Other standard accessories which are not specifically mentioned but are usually and provided with lightning arrester of similar type and rating for efficient and trouble free operation.
- vi. Name plates fixed on lightning arresters giving full technical details.
- vii. The clamps and connectors on arrester terminals for connection to Purchaser's line conductor and the connection between incoming transmission line and LA will be in the Contractors scope.

g) Drawings/ documents to be furnished for Purchaser's approval:

- i. Technical Particulars
- ii. GA drawing of LA indicating weight and overall dimensions
- iii. GA drawing of insulating base, discharge counter, terminal assembly
- iv. Bill of Material
- v. Mounting arrangement (base plate details) on the structure
- vi. QAP for Lightning Arrester.

1.4.2.8 Chain Link Fencing and Gravel Filling:

- a) The work of erecting chain link fencing includes excavation, brick wall construction, erection of angle/ channel supports, providing chain link mesh on angle/ pipe frame barbed wire fencing at the top, concreting of support members, painting the complete structure and white washing the walls. All materials, hard wares, labours etc. are in the scope of contractor.
- b) Fencing height shall be minimum 2.0 meter & shall be complying with CEA guide lines requirements.
- c) Gate for entry in the fenced compound shall be fabricated from pipes of heavy duty class. Design of gate shall be got approved from the engineer in charge before starting the fabrication work. All necessary hard wares, fittings, stoppers, locking arrangements with brass pad locks of 100 mm size are in the scope of gate works. Gates shall be self supporting type.

1.4.3 HT METAL ENCLOSED SWITCHGEARS:

1.4.3.1 Applicable Standards:

- a) The design, material, construction, manufacture, inspection and testing of Switchgear shall conform to the latest applicable standards & comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.
- b) The equipment shall also conform to the latest standards specified below. In case of conflict between the standards and this specification, this specification shall govern.

Circuit Breakers	IS : 13118/ IEC : 56, 694, 62271
Metal Enclosed Switchgear	IS : 3427/ BSEN:60298/ IEC:298 / IEC 265
Current Transformers	IS : 2705/ BS : 7626
Voltage Transformers	IS : 3156/ BS : 7625/ IEC: 186
Arrangement for switchgear bus bars, main connections and auxiliary wiring	IS : 5578, 11353
Busbar Support Insulators	IS: 2544/ BS : 3297/ IEC : 273
Degree of Protection	IS : 13947 (Part 1)/ IEC : 947-1 / IEC : 60529
Electrical Relays for power system protection	IS : 3231, 3842/ BS : 142 / IEC : 255
Electrical Indicating Instruments	IS : 1248 / BS : 89 / IEC : 51
High Voltage Fuses	IS: 9385 / BS : 2692 / IEC : 282
AC Electricity Meters	IS : 722, 8530 / BS : 5685 / IEC : 145, 211
Specification for copper rods and bars for electrical purposes	IS : 613

Code of practice for phosphating iron and steel	IS : 6005 / BS : 3189
Alternating current switches for voltages above 1000 V	IS: 9920 / IEC : 129, 265 & 298
Low Voltage Fuses	IS : 13703 / BS 1362 / IEC 269
Toggle Switches	IS : 3452 / BS : 3676
Code of practice for selection, installation and maintenance of switchgear and control gear	IS : 10118
Control Switches	IS:6875/BSEN 60947/IEC : 947
HV Cable Termination	IEC 62329

The switchgear shall be metal enclosed, indoor type with vacuum circuit breakers fully draw out. Circuit breakers of same ratings shall be completely inter-changeable with one another. Separate metal enclosed compartments for (a) control, metering & relaying devices, (b) circuit breaker, (c) phase bus bars, (d) Instrument transformers & (e) input/ out power cable terminations and each section shall be in conformance with Loss of Service Continuity LSC 2B.

The rated capacity of the breaker & switchgear configuration (no. of incomer & outgoing breakers, minimum ratings, protections, indications, annunciations, instruments etc.) shall be as per reference electrical Single Line Diagram & this specification given in table below:

Sr. No	Description	Rating
a)	Rated Voltage	22 kV and 11 kV
b)	Bus bar rating	*A
c)	Short Circuit Rating	26 kA for 1 Sec
d)	Type of breakers	VCB
e)	Bus bars material	Electrolytic Copper (Silver plated at

		Joints)
f)	Degree of Protection	IP4X (as minimum)

Auxiliary relays for multiplication of contacts for following transformer protections shall be provided for oil type Transformer feeders:

- a) Buchholz Protection Alarm & Trip
- b) Winding Temperature Alarm & Trip
- c) Oil Temperature Alarm & Trip
- d) Pressure Relief Device Trip
- e) Oil level gauge (MOG) Alarm
- f) Oil Surge Relay (OSR) Trip

The circuit breakers should be able to carry the rated current continuously under site conditions without exceeding the permissible temperature rise for design ambient temperature outside the switchgear cubicle as specified.

Bus bar material for switchgear panel shall be electrolytic Copper. Bus bars shall be fully insulated, supported on insulators capable of withstanding dynamic stresses due to short circuit. Maximum temperature of the main bus bars and bus bar connections, under operating conditions, when carrying rated normal current at rated frequency shall not exceed 90/ 105°C for non-silver plated/ silver plated joints as per IEC 60694. Bus bar temperature limits shall be adhered to without forced cooling method. 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.

The circuit breaker shall be fully drawn out type in horizontal with test, service and isolated positions. In test position, the circuit breaker shall be capable of being tested for operation without energizing power circuits. Additional 2 (Two) normally open (NO) contacts of test and service positions shall be available for Client's use, after meeting all the interlocks/ permissive.

Switchgear shall comprise rigid welded structural frame enclosed completely by sheet steel - minimum 2.5 mm thick (hot rolled) or 2.0 mm thick (cold rolled),

smooth finished, leveled and free from flaws. Switchgear cubicles shall be provided with bottom sheet steel plates of 2.5 mm thickness. Cable compartments shall be fitted with removable plates of minimum 2.5 mm thickness for fixing cable glands. Cable gland shall be double compression type. For single core cable, removable plates of non-magnetic material shall be provided.

The switchgear panel shall be powder coated with shade RAL-7032 with minimum thickness 80 microns with structured finish and height not exceeding 2300 mm.

For vacuum circuit breakers necessary hardware for surge suppression shall be provided to take care of switching surge.

Circuit breaker shall be provided with a minimum of 6NO + 6NC contacts per pole exclusively for the Client's use. All spare contacts of the circuit breaker shall be wired up to the terminal block.

The breaker closing coils, tripping coils, indications, annunciations shall be rated for 24/ 30V or 110V DC. The spring charging motor shall be suitable for 240V AC. Space heater, power socket, panel illumination lamp shall be fed from 240V, 50 Hz, 1 phase raw power supply. All lamp test facility shall be provided with push button.

The current transformers shall be mounted in the fixed portion of the switchgear expansion panel. 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. Adequate space shall be available for termination using heat shrinkable type cable termination in CT compartment.

The switchgear shall have complete interlocking arrangement at the 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. Breaker trolley if required shall be provided with breaker.

Automatic safety shutters shall cover live parts when the breaker is withdrawn and all other standard safety features shall be provided.

All the High Voltage compartments i.e., Circuit Breaker, Bus Bar, and Cable Compartments shall be separated from each other by metallic partitions in line with

IEC-62271-100/200. These compartments must have pressure relief flaps for exit of gas due to internal arc to ensure operators safety. All the HV design must ensure conformity to IEC-62271-100/200 and must be type tested for Internal Arc Tests.

All non current carrying metal work of the switchgear panel shall be effectively bonded to the earth bus. Earth bus-bar shall be extended outside the switchboard at the ends. All hinged doors & bolted joints in the body of switchgear shall be earthed through flexible copper earthing braid of adequate cross section.

Terminal blocks shall be of stud & nut type, 1100V 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 with short circuiting and earthing facility. All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks with 20% spare terminals. All terminals of different control voltages shall be separate from each other. Stud type terminals and ring type lugs shall be used for control cables.

The sizes of wire for CT circuit shall be minimum 2.5 mm² multi-stranded copper conductor PVC insulated and for others minimum 1.5 mm² multi-stranded copper conductors PVC insulated. Ring type lugs suitable for termination of 2.5 sq mm copper wires shall be used. Colours of the secondary/ auxiliary wiring should conform to IS 375/ 1963 and latest amendments thereof.

All wiring shall be neatly run and group of wiring shall be securely fixed with clips so that wiring can be checked without necessity of removing the clamps. Ferrules with number shall be provided on both end of the wiring, i.e. straight + cross ferruling shall be done. Printed ferrules (tubular type- cut to size after printing) white with black lettering shall be provided. Printing shall be done with the indelible ink.

All protective relays shall be in draw out cases with built in test facilities. All auxiliary relays and timers shall be supplied in non draw out cases. Externally operated hand reset indicators shall be provided on all electro-mechanical relays and timers. Timers shall be of electromagnetic or electronic type only. All spare contacts of all relays/ timers shall be wired to terminal block. All relays shall be of self reset type, unless otherwise specified.

Main Protection relays shall be numerical type and shall be supplied with latest version software without any extra cost. Relays and protection shall be enabled for SCADA with IEC 61850 protocol & Modbus RS-485.

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.

Indicating lamps shall be panel mounting type of the colour specified and of multi chip/ cluster LED type only.

Each circuit breaker panel shall be complete with the following:

- a) T-N-C control switch, spring return to neutral position.
- b) Key operated local/ remote selector switch stay put type.
- c) Red, green, amber, white and blue coloured clustered type LED indicating lamps for breaker- ON, OFF, auto trip, trip circuit healthy and spring charged and breaker in Test/ Service position shall be provided.
- d) Push Button for all lamp test facility.
- e) 8 window (for Incomer Panel) or ICOG/ 16 window [for each Outgoing (transformer feeder) panel] annunciator with all associated accessories as per detailed in electrical SLD.
- f) Double pole control supply switch with MCB.
- g) Electrical anti pumping relay.
- h) Panel illumination lamp (CFL) with MCB/ switch.
- i) Space heater with adjustable thermostat, MCB.
- j) 5/15A, 1 phase receptacle with MCB.
- k) Potential indicating multichip/ clustered type LED lamps (R, Y, and B) for incomer/ ICOG breaker.
- l) Components as per electrical SLD.
- m) Emergency trip push button (ETPB- Mushroom type, Red coloured latchable type)

n) Test Terminal Block (TTB)

o) Mechanical trip push button to trip the breaker when control supply is lost. The push button shall be shrouded type. Mechanical close push button provided shall be accessible only after opening of the front door.

p) The panel front of the circuit breaker truck shall have following devices/ indications:

- i. Mechanical push button for breaker open.
- ii. Mechanical indications for spring charge / discharge.
- iii. Mechanical indications for breaker test/ service position.
- iv. Mechanical indication for breaker ON/ OFF.
- v. Operation Counter.
- vi. Device for manual charging of closing spring.

All analogue indicating meters shall be 144 x 144 mm size taut band with 2400 Scale. All indicating meters shall be provided as per enclosed electrical Single Line Diagram.

Multi Function Meter (MFM) shall be micro-processor based electronic meter and shall have facility for on line monitoring, reading display of each parameter and shall be provided with RS-485 communication port. Analogue Ammeter & Voltmeter shall also be provided as per electrical 'Single Line Diagram'.

No extra charges shall be payable to Contractor in the event of any change in the contact configuration of relays i.e. from normally open (NO) to normally closed (NC) and vice versa. All wiring and necessary hardware for the completeness of the schemes shall be included in the scope of Contractor.

All operating switches shall be accessible without opening the compartment door.

All transformer outgoing feeders shall be suitable for interrupting transformer magnetizing currents. The breaker shall be electrically interlocked with downstream LT breaker such that if HT breaker trips, LT breaker shall also trip, and LT breaker cannot be closed until HT breaker is closed.

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.

It shall be entirely responsibility of the Contractor to ensure that characteristics of CTs, VTs and all other devices offered by him/ her are such as to be suitable for the purpose for which they are intended.

Switchgear shall be suitable for easy extension on both the sides. It shall be possible at a later stage to add cubicles on both the sides of the switchgear by extending the bus-bars.

All power and control cables entry shall be from bottom/ top to suit the site condition. The cable compartment shall house all power cable connections along with associated cable terminations.

All control cabling/ wiring shall be done using 1.1kV grade, multi-stranded, Cu conductor, PVC insulated FRLS cables. Panel wiring shall be securely supported, neatly installed by lacing, and tying, readily accessible and connected to equipment terminals and terminal blocks. All the accessories such as cable troughs, cable ties, covers etc. shall be of fire retardant material.

Breaker handling trolley shall be provided if required. This shall be complete with all necessary accessories.

Earthing Switch shall be provided for bus-bar earthing for incomer panel and for cable earthing on the outgoing breaker panel with necessary interlocks. The panel earthing shall be extended up to cable alley for armour earthing.

Required suitable Cable/ extension adopter boxes for power cables shall be a part of HT panel. The termination kit shall be heat shrinkable type only. Cable lugs for all power, control & instrumentation cables connections shall be supplied. The lugs shall be tinned copper/ Aluminum depending on cable conductor and of solder less crimping type.

Padlocking facilities shall be provided for locking the shutters positively in closed position in all the panels. All door locks shall be provided with special keys to ensure opening by authorized personal only.

Caution name plate, "Caution Live Terminal" shall be provided at all the points where the terminals are likely to remain live and isolation is possible only at remote end i.e. incomer to the switchboard.

Danger notices in three languages (Hindi, English & Gujarati) and in line with the requirements of IS 2551 shall be riveted & not pasted at appropriate locations of the switchgear.

Feeder and board name plates to be provided at front and rear of switchboard.

Panel illumination lamp shall be 9/ 11W CFL with fixture & shall be provided with door limit switch.

1.4.3.2 Relays:

- a) All relays as indicated in electrical 'Single Line Diagram' shall be mounted on the switchgear panels. The relays shall be in draw-out case, flush mounted type.
- b) All the unit protection relays such as 51NS shall be separate relays & elements (50/ 50N, 51/ 51N, 51NS etc.) available in numerical relays shall not be used for this purpose.
- c) In case the primary protection relays offered by Contractor do not have adequate number of contacts for protection/ interlock schemes. Contractor shall supply suitable contact multiplying auxiliary relays as required. Also all necessary auxiliary relays as required to meet the Client's final control/ protection/ interlock schemes shall be provided by the Contractor.
- d) Relays shall be Numerical type. Test terminal block for testing shall be provided. Relays shall be suitable for 1/5A CT secondary rating as indicated in respective Single Line Diagram. Relays shall be suitable for SCADA with IEC 61850 protocol & Modbus RS-485.
- e) Relay & Metering used shall be as per following Make & model Nos. "OR equivalent" shall be construed as Equivalent from the approved Makes mentioned elsewhere in the specifications.

RELAYS	
Over-current & Earth Fault protection [IDMT & Instant.]	HPSEB Approved Make

(50/50N, 51/51N)	
Master Trip/ Lock out Relay (86)	HPSEB Approved Make
Stand by Earth Fault Relay (51NS)	HPSEB Approved Make
Contact multiplication relay	HPSEB Approved Make
Trip Circuit Supervision Relay	HPSEB Approved Make
Comprehensive Motor Protection relays	HPSEB Approved Make
METERING	
Analogue Ammeter	HPSEB Approved Make
Analogue Voltmeter	HPSEB Approved Make
Multi Function Meter (MFM)	HPSEB Approved Make

- f) Lockout relay-86 shall be having minimum 6 NO + 6 NC contacts.
- g) All relays shall have clear identification on the associated panel by well-written inscription plates. Where indications are provided by flag relays or LEDs, these shall also be specifically identified by permanently fixed inscription adjacent to them.
- h) The final relay ranges of each relay shall be decided at detailed engineering stage, if it is found that the offered relay range is not suitable for the intended application, the Contractor shall change the relay of appropriate range without any commercial / delivery implications whatsoever. The relay shall be subject to approval of Client's representative.
- i) Contractor shall furnish recommended relay settings with backup calculations & approval for the same has to be obtained from Purchaser/ Consultant. Entire Relay co-ordination shall be carried out in ETAP 12.5 version or latest available during detailed engineering. The Contractor shall obtain all interface data from all concerned.

- j) All relay/ auxiliary relay coils shall operate satisfactorily between 85% to 115% of rated control voltage.
- k) It is responsibility of the Contractor to include accessories like auxiliary CTs, VTs and all other necessary devices as required for satisfactory performance of relay and protection scheme even if not indicated in drawings / data sheets. Testing facilities like test switches / test plugs shall be provided for testing of each individual relays.
- l) Performance tests shall be conducted at site and also supervised by Contractor for all the equipment's to prove the guarantee.
- m) Prices quoted shall include the cost of all routine tests specified in relevant standard & as mentioned below. As regards type tests, copies of the earlier test certificates carried out on equipment of similar or higher ratings but not older than 5 years shall be furnished along with the offer.

1.4.3.3 Current Transformers

Current Transformers shall satisfy following requirements:

- a) Current transformers for metering & protection shall be cast resin (class of insulation B or better). The CT ratios/ protection class shall be as shown in 'Single Line Diagram'.
- b) Rated VA burden for metering/ protection CTs shall not be less than 15VA or 120% of total VA burden whichever is higher.
- c) The accuracy class for metering CT shall be 1.0 or better.
- d) It shall be responsibility of Contractor to ensure that CTs are suitable for correct and satisfactory operation of the instruments/ relays connected across them.
- e) Short time current rating and momentary withstand rating of CTs shall be as per breaker short time current withstanding capacity.
- f) All CTs shall have secondary rating of 1A or 5A.

1.4.3.4 Potential Transformers

Potential Transformers shall satisfy following requirements:

- a) Potential transformers for metering/protection shall be provided as per incoming voltage level and frequency. The PT ratios shall be as per HPPTCL/HPSEB requirements.
- b) Rated VA burden for metering/ protection PTs shall not be less than 100VA or 120% of total VA burden whichever is higher.
- c) The accuracy class for metering PT shall be Class 1.0
- d) It shall be responsibility of Contractor to ensure that PTs are suitable for correct and satisfactory operation of the instruments connected across them.
- e) Fuses on primary side shall have rupturing capacity equal to the switchgear rating.
- f) For PT's MCB shall be provided on secondary. MCB trip contact to be wired up for annunciation.

1.4.3.5 Maintenance Requirements :

- a) Contractor 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 Contractor shall supply one complete set for each type of equipment for the purpose.
- b) Contractor shall include supply of start-up and essential spares.
- c) Contractor shall furnish detailed inter-panel diagrams, terminal connection wiring diagram, and detailed component layout drawings to carry out maintenance work.
- d) Contractor shall ensure the use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to national standard.

1.4.3.6 Earthing:

- a) An earthing bus shall be provided at the bottom and extend throughout the length of the switchgear. It shall be bolted / welded to the frame work of each unit and each breaker earthing bus.
- b) 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 of adequate size.

- c) Positive earthing of the circuit breaker frame shall be maintained both in service and test position.

1.4.3.7 Annunciators:

- a) Microprocessor based alarm annunciators shall be provided for generating audio visual alarms for each abnormal condition. Facia annunciators, suitable for operation on 24/ 30V or 110V DC (as applicable) shall be provided.
- b) Each alarm shall initiate the operation of both visual and audible devices equipped with 'Mute', 'Acknowledge' and 'Reset' push buttons common to annunciators on all switchgear aligned together and a 'Lamp test' push button for each annunciator on individual panels.
- c) Annunciator shall be of facia type with translucent plastic window for each alarm point. Annunciator facia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective facia light is lighted provided with two lamps connected in parallel on each facia window with series resistors. Lamps shall be clustered LED type.
- d) All facia annunciator points shall be suitable to accept external contacts of either 'NO' or 'NC' self or hand reset type for initiating the annunciation sequence.
- e) Annunciators shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds annunciating subsequent faults with the specified sequence immediately after acknowledging the previous fault.
- f) Facia Window shall be of minimum size of 35 mm x 50 mm.
- g) During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the "lamp test" circuit and shall start flashing.
- h) The sound intensity of each audible device shall be suitable for the maximum sound level of its environment.
- i) The sequence of alarm should be user selectable by dip switch. The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a future alarm condition occurs
- j) Annunciator shall be designed for an operating sequence indicated below:

Alarm Condition	Fault Contact	Audible Alarm	Visual Alarm
Normal	Open	Off	Off
Abnormal	Closed	On	Flashing
Acknowledge	Open	Off	Steady on
Reset	Open	Off	Off
Lamp Test	Open	Off	Steady on

1.4.3.8 Cable Terminations:

- a) Necessary number of 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.
- b) 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.
- c) All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc., shall be supplied.

1.4.3.9 Tests:

- a) Routine tests and acceptance tests as per the applicable IS /IEC standards shall be carried out in the presence of Client / Client's representative.
- b) Type test certificates for internal arc test, SC withstand & Impulse test shall be furnished with the Bid (not older than five (5) years) from CPRI or other independent agency
- c) The test equipment, meters, instruments etc. used for testing shall be calibrated at recognized test laboratories at regular intervals and valid certificates shall be made available to the Client / Client's representative at the time of testing. The calibrating instruments used as standards shall be traceable to national/international standards.

1.4.3.10 Drawings/ Documents Required

The following drawings/ documents to be furnished by the contractor for Purchaser's approval

- a) Technical Data Sheet
- b) GA Drawing
- c) Wiring Schematic
- d) Bill of Quantities
- e) QAP

1.4.4 DISTRIBUTION TRANSFORMERS:

Applicable Standards : Transformer shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards and codes of practice specified as under. In case of conflict between the applicable reference standards and this specification, this specification shall govern.

Transformer : IS 1180-2014, IS 2026, BS 171, IEC76,CBIP Pub No. 317

Fittings & Accessories: IS 3639

Climate proofing: IS 3202 BS-CP-1014IEC 354

Loading of oil immersed: S 6600 BS-CP-1010IEC 296

Oil : IS 335 BS-148IEC 137

Bushing for > 1000 V, AC: IS 2099 BS-223 IEC 144

Bushing for < 1000 V, AC: IS 7421 BS-223 IEC 144

Degree of protection : IS 13947 IEC 76

Tests : IS 2026 BS-171 IEC 76

Tolerance on guaranteed : IS 2026

Particulars

Buchhloz relay: IS 3637

Electrical insulation classified by thermal Stability: IS 1271 BS 2727 IEC 85

Auxiliary Transformer: IS 1180

Code of practice selection, Installation for & maintenance of transformer: IS 10028

This specification is for complete 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, storage at site, shifting from the place of storage to place of installation, installation, testing and commissioning for two winding, three phase, 50 Hz, outdoor type, distribution transformer of (*)kVA, ONAN cooled, connected in Dyn11 with OCTC/ OLTC on HV winding & other accessories as specified.

(*Transformer rating shall be finalized based on the transformer design criteria, specified in this specifications)

% Impedance shall be as per IS 1180-2014/ IS 2026: 1977 – (Part-1).

The values of load- losses and No-load losses shall be as given in IS 1180-2014.

The Purchaser reserves the right to reject the transformer if the same does not meet the specification requirement as follows:

- a) No load loss exceeds the guaranteed value by 20% or more.
- b) Load loss exceeds the guaranteed value by 20% or more.
- c) Impedance value differs the guaranteed value by +10% or more (zero negative tolerance)
- d) Oil or winding temperature rise exceeds the specified value by 5 deg C
- e) Transformer fails on impulse test.
- f) Transformer fails on power frequency voltage withstand test.
- g) Transformer is proved to have been manufactured not in accordance with the agreed specification

The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost.

If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Purchaser/ Client reserves the right to accept the rejected transformer until the replacement transformer is made available. Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Contractor's cost

Transformer Protections: The following protections shall be provided for a distribution transformer:

Over-current protection - Instant (50/51)	Trip (Relay In HT Panel)
Earth fault protection - Instant (50N)	Trip (Relay In HT Panel)
Buchholz protection relay (63) [For transformers of 500 KVA & above]	Alarm + Trip
Oil temperature indicator (OTI - 49O)	Alarm + Trip
Winding temperature indicator (WTI - 49W) [for transformer of 1000 KVA & above]	Alarm + Trip
Magnetic Oil level gauge (MOG)	Alarm
Oil Surge Relay (OSR) [For transformers with OLTC]	Trip - For OLTC
Pressure relief device (PRD) [For transformer of 800 kVA & above]	Trip
Stand by Earth fault protection (51NS) with CT in transformer neutral [For transformer of 1600KVA & above]	Trip (Relay In HT Panel)

An air insulated cable box with disconnecting chamber shall be provided on HT side of transformer for cable termination.

For the pole mounted transformers (i.e. transformers ≤ 250 kVA), suitable orientation of HV porcelain bushings shall be ensured for direct termination of ACSR conductor from Double Pole Structure.

For transformers above 250 kVA rating, elevated foundation/ plinth of suitable height shall be provided.

All the Civil works such as, transformer foundation, Oil Soak Pit, Burnt oil pit as per CEA guidelines & IS 10028 requirements shall be considered in Contractor's scope.

Ambient temperature of 50°C shall be considered for transformer design. Temperature rise shall be 40°C for Oil temperature and 45°C for winding temperature. Hot spot temperature limits shall be complying with IS 1180, IS 2026, IS 6600 & IEC 60076-2:1993 & it shall be limited to 98 Deg. C.

The limits of hot spot temperature mentioned above will have to be satisfied by the manufacturer by carrying out the heat run test at the lowest negative tap. This test shall be carried out by feeding 1.1 times the total losses at 75°C at highest current tap.

Neutral of LV winding shall be 50% rated.

Suitable dial type instruments/indicator with alarm and trip contacts shall be provided for monitoring of following parameters for the transformer. The settings shall be site adjustable.

Winding Temperature Indicator (WTI)	1 No local + 1 No remote on RTCC
Oil Temperature indicator (OTI)	1 No local + 1 No remote
Magnetic oil level gauge (MOG)	i. No local

The bushing CT required in neutral connection for back up earth fault protection shall be provided before bifurcation of neutral.

Accessories listed below shall be provided for the transformer unless noted otherwise.

- a) Anti-earthquake clamping device
- b) Marshalling Box
- c) All interconnection cables, cable accessories for connection between the transformer marshalling box & other devices mounted on the transformer and inter-connection cables for all the associated equipments/ panels including cable termination accessories such as glands, lugs etc.
- d) Foundation bolts & hardware, mounting channel & support structures for marshalling boxes, junction boxes etc.
- e) All MS components including steel bolts & nuts shall be hot dip galvanized.
- f) Automatic self-resetting type pressure relief device with trip contacts wired up to marshalling box.
- g) Additional neutral bushing.
- h) Conservator with lifting lugs (for transformers 50 KVA and above with rated voltage up to 11 kV, and all rating above 11kV with oil filling hole with cap and a drain plug.) Conservator shall be complete with plug, sample and drain valve and a shut-off valve on the pipe connection between the transformer tank and conservator to permit removal of the conservator
- i) Bushing Terminals or cable boxes complete with connectors for the Purchaser's external conductors or cable.
- j) Neutral bushing terminal complete with connector for earth conductor.
- k) Four plain rollers in place of fixing channels. The rollers shall be bidirectional, with suitable corrosion-free bearings, suitable for 90 degree rotation & lockable in both directions and of the detachable type.
- l) Inspection covers (for transformers of 1000 KVA and above).
- m) Rating and terminal marking plates
- n) Two earthing terminals for body earthing
- o) Drain cum sampling valve with plug or cover plate.

- p) Dehydrating Silica Gel Breather equipped with a silica gel dehydration capsule and oil seal to eliminate constant contact with the atmosphere.
- q) Thermometer pocket with mercury in glass bulb thermometer.
- r) Radiator with air release plug, lifting lug, drain valve and with shut off valves.
- s) Conservator with lifting lugs, oil filling cap & drain plug.
- t) Prismatic oil level gauge (on conservator) with minimum level marking.
- u) Jacking Lugs (Transformers weighing above 3000 Kg)
- v) Filter Valves
- w) Explosion vent with diaphragm/ pressure relief valve (for transformers 50 KVA and above). The device shall be rain-proof after operation. For transformers of 500 KVA and above an equalizer pipe connecting the pressure relief device to the conservator shall be supplied
- x) Base channels for fixing on a platform or plinth
- y) Lifting lugs for top cover & active part.
- z) Lifting lugs for lifting complete transformer with oil.
 - aa) Lifting lugs for lifting core & coils.
 - bb) Pocket for O.T.I & W.T.I.
 - cc) Neutral C.T with terminal box.
 - dd) Earthing bar with insulator support.
 - ee) All indicating lamps shall be multichip LED Type.
- ff) Dial type thermometer (150 mm Dia.) with two contacts for oil temperature 'high' and 'too high' alarms. Each contact shall be electrically independent and brought out to separate terminals, rated 220 V.D.C; minimum 0.5A.
- gg) Magnetic oil level gauge (150 mm dia. 240 degree scale) with low oil level alarm contact for transformers fitted with conservator. Contact rating suitable for 220V D.C., minimum 0.5A.

- hh) Gas actuated Buchholz relay, double float type with a valve between the relay and the conservator.
- ii) Gas sampling device at an accessible height and an air release cock for Buchholz relay.
- jj) Winding temperature indicator, consisting of:
 - i. Temperature sensing element. Separate PT100 for digital signal shall be provided as temperature sensor
 - ii. Turret mounted CT.
 - iii. Local Winding temperature indicating instrument (150mm Dia.) with electrically independent contact(potential free contact) brought out to separate terminals for winding temperature 'high' and 'too high' alarms. Contacts shall be suitable for 220V DC, rated minimum 0.5A.
- kk) All digital outputs for control / remote annunciation shall be provided with at least two change-over contacts for alarm & two change-over contacts for trip conditions. Auxiliary relays, if required, to provide change-over contacts suitable for Purchaser's equipment are deemed to be included in the Contractor's scope.
- ll) Valves: Valves shall be of Gun Metal material & of suitable diameter for their intended purpose. Following valves shall be provided for each oil immersed transformer.
 - i. One (1) top filter valve with blanking plate.
 - ii. One (1) bottom filter valve with blanking plate
 - iii. One (1) bottom sampling valve with blanking plate
 - iv. Two (2) Shut-Off / Gate Valve for OLTC Part of Conservator (on both sides of Oil Surge relay)
 - v. Two (2) Shut-Off / Gate Valve for Main Conservator(on both sides of Buchholz relay)
 - vi. One (1) Drain valve with blanking plate for Conservator
 - vii. One (1) bottom drain valve with blanking plate for complete Transformer

- viii. One (1) top sampling valve with blanking plate
- ix. Radiator shut off valves with blanking plates between radiator head & tank.
- x. Oil filling valve with blanking plate for Main & OLTC conservator.

1.4.4.1 General Constructional Features of Transformer:

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 construction shall be suitable for Seismic Data (As per latest edition of IS 1893) or elsewhere in the specification.

a) Tanks:

- i. The exterior of tank and other steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of an oil and weather-resistant nature, preferably of distinct colour from the prime and finish coats. The final coat shall be of a glossy, oil and weather resisting non-fading paint of specified shade. The interior of the tank shall be cleaned by shot blasting and painting with two coats of heat resistant and oil insoluble paint.
- ii. Steel bolts and nuts exposed to the atmosphere shall be galvanized.
- iii. Vacuum & Pressure Tests
- iv. Various Vacuum & Pressure Tests for tank, conservator, radiator, pipes etc. shall be as per mentioned in the CBIP Manual on Transformer – Publication no. 317: 2013 & latest edition thereof.
- v. The material used for gaskets shall be cork neoprene or approved equivalent.

b) Core:

CRGO material:

- i. The magnetic circuit shall be constructed from high grade cold-rolled non-ageing grain oriented silicon steel laminations and shall be of 'core' type.
- ii. The insulation structure for the core to bolts and core to clamp plates shall be such as to withstands BIL & Lightning Impulse Voltage
- iii. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service.
- iv. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated.

Amorphous Metal:

- i. The core shall be high quality amorphous ribbons having very low loss formed into wound cores of rectangular shape, bolted together to the frames firmly to prevent vibration or noise. The complete design of core must ensure permanency of the core loss with continuous working of the transformers. The value of the flux density allowed in the design shall be clearly stated in the offer. Curve showing the properties of the metal shall be attached with the offer.
- ii. Core Clamping - Amorphous Metal Transformers:
 - Core clamping shall be with top and bottom U-shaped core clamps made of sheet steel clamped with MS tie rods for efficient clamping.
 - MS core clamps shall be painted with varnish or hot oil resistant paint.
 - Suitable provision shall be made in the bottom core clamp / bottom plate of the transformer to Arrest movement of the active part.
- iii. The transformer core shall be suitable for over fluxing (due to combined effect of voltage and frequency up to 12.5% without injurious heating at full load conditions and shall not get saturated. The Bidder shall furnish necessary design data in support of this situation.
- iv. No load current shall not exceed 2% of full load current and will be measured by energizing the transformer at 433 volts, 50 c/s on the secondary. Increase of voltage of 433 volts by 12.5 % shall not increase the no load current by Max. 5% of full load current. Test for magnetic balance by connecting the LV phase by phase to rated phase voltage and measurement of an, bn, cn voltage will be carried out.

c) Windings

- i. Windings shall be of electrolytic grade Copper of 99.9% purity unless specifically approved by the Purchaser.
- ii. Windings shall be of insulated Copper wire or Copper strip.
- iii. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core.
- iv. Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service.
- v. The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture within the insulation.
- vi. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.
- vii. Materials used in the insulation and assembly of the windings shall be insoluble, non- catalytic and chemically inactive in the hot transformer oil, and shall not soften or be otherwise affected under the operating conditions.
- viii. Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive be used which will seal the coil and prevent evacuations of air and moisture and impregnation by oil.
- ix. Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil. Steel bolts, if used, shall be suitably treated.
- x. Terminals of all windings, and if stated also of stabilizing windings, shall be Brought out of the tank through bushings for external connections.
- xi. Windings shall be of copper and the conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperatures along the windings.

- xii. The sequence and orientation of HV/LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.
- xiii. Transformer shall operate without injurious heating at the rated KVA and at any voltage up to $\pm 10\%$ of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstands capability.
- d) Internal Earthing: The framework and clamping arrangement of core and coil shall be securely earthed inside the tank by Copper strap connection to the tank.
- e) Terminations:
- i. Transformers shall be fitted either with bushing insulators or with air insulated cable boxes / air insulated cable box with disconnecting chamber, as per requirement based on transformer HV incomer.
 - ii. The neutral of the star-connected winding shall be brought out to a separate bushing terminal. The neutral bushing shall be provided on the tank side to facilitate lead of the earth conductor down to the ground level. For transformers 1000 KVA and above, tank mounted insulators shall be provided for supporting the neutral earthing bar of specified section, along its run from the neutral bushing to ground-level.
- f) Bushings:
- i. Bushings shall be designed and tested to comply with the applicable standards specified in the specifications.
 - ii. Bushing rated for 400A and above shall have non-ferrous flanges and hardware.
 - iii. Fittings made of steel or malleable iron shall be galvanized.
 - iv. Bushings shall be supplied with terminal connector clamp suitable for connecting the bushing terminal to the specified conductor/ cable.
 - v. Dimensions of the bushings of the following voltage class shall conform to Indian Standards mentioned below. The bushings shall be provided from the registered vendors of the HPPTCL/HPSEB.

Voltage	Indian Standards	For metal parts
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class	or porcelain parts	
1.1KV	IS-3347/part-I/Sec.I	IS-3347/Part-I/Sec,2 (As per IS-1180)
12 KV	IS-3347/part-I/Sec.I	IS-3347/Part-I/Sec,2
24 KV	IS-3347/part-IV/Sec.I	IS-3347/part-IV/Sec. 2

- vi. A minimum phase to phase clearance of 75mm for LV (upto 1.1KV bushing) and 255mm for HV (3.3KV and above) bushings shall be obtained with the bushing mounted on the transformer.
- vii. The bushings shall be fixed on sides with pockets in the same plane. Arcing horns shall not be provided and instead brass caps shall be provided.
- viii. The LV bushing shall be so located that even under the hottest conditions the level of the transformer oil shall be below the opening meant for fixing the LV bushings. The LV jumpers and bushing material shall be selected and designed for this condition.
- ix. The design of the internal bushing for LV shall be such as to provide adequate earth clearance as stipulated in the clause 10, 2.1 of IS1180 Part.I and creepage distance as per Clause 7.1 of IS 2099. All other tests as per relevant standards shall be applicable. The LV bushing and HV bushing stems shall be provided with suitable terminal connectors as per IS 5082 so as to connect the jumper without disturbing the bushing stem. High voltage phase windings shall be marked both in the terminal boards inside the tank and on the outside with capital letters 1U, 1V, 1W and low voltage windings for the same phase marked by corresponding small letters 2u, 2v, 2w. The neutral point terminal shall be indicated by the letter 2n. Terminal connectors shall be type tested as per IS 5561. The vector diagram plate shall clearly indicate the method adopted for marking the terminals both outside and interior.

g) Bushing Current Transformers:

- i. Whenever applicable, bushing shall be supplied with current transformers.
- ii. Secondary leads, including tapplings, shall be brought to a weatherproof terminal box near the bushing.
- iii. Bushing C.T. nameplate shall be mounted on the tank adjacent to the terminal box.

h) Cable Boxes and Disconnecting Chamber:

- i. The cable boxes, wherever required as per the prescribed criteria, shall be complete with cable joint fittings or sealing ends as required, tinned copper lugs to suit specified cable, compound and all other accessories including compression type glands, armour earth clamps and body earth terminal.
- ii. For Cable type of terminations, disconnecting chamber shall be provided to enable the transformer to be removed without unsealing the cables or draining oil from the main tank. The disconnecting chamber shall be air insulated and complete with seal-off bushings, removable flexible connectors/ links and removable covers.
- iii. Cable boxes shall be designed to accommodate all cable joint fittings or sealing ends as required, including stress/ cones or other approved means for grading voltage stress on the terminal insulation of cables operating at voltages of 22 kV and above.
- iv. Phase to phase and phase to ground clearances within the chamber shall be such as to enable either the transformer or cable to be subjected separately to HV tests.

i) Marshalling Box:

- i. Whenever fittings such as OTI/ WTI, temperature indicators with auxiliary contacts, Buchholz relay, bushing CTs etc. are provided the marshalling box shall be provided to marshal in it all the contacts/ terminals of electrical devices mounted on the transformer.
- ii. It shall be in the Contractor's scope to provide interconnection cabling between the marshalling box and the accessory devices by either PVC insulated, FRLS wires in GI conduits and/ or XLPE insulated, inner & outer extruded PVC, armoured cable

and necessary compression type brass cable glands at the marshalling box for the above mentioned cables as well as for terminating the incoming cables from remote panels.

- iii. The marshalling box shall be tank mounted (at easily accessible location), outdoor type, IP 55 protected, weather-proof, sheet-steel (2 mm thick) enclosed, with hinged door having padlocking facility and painted as per paint shade approved by the Purchaser. All doors, covers and plates shall be fitted with Neoprene gaskets. Bottom shall be at least 600 mm from floor level and provided with gland plate and cable glands as required. Top surface shall be sloped.
- iv. The marshalling box shall be provided with glass window so as to make the WTI and the OTI dials visible from the outside without opening the door.
- v. All contacts for alarm, trip and indication circuits shall each be potential free, wired for auxiliary DC supply as specified and brought out to separate terminals at the terminal blocks in the marshalling-box. Terminals shall be rated for 10A. Wiring shall be 1.1 kV grade, with multi-stranded, copper conductors of sizes not smaller than 1.5 sq.mm for control and 2.5 sq. mm for CT circuits. CT terminals shall be provided with shorting facility and earthing.
- vi. The marshalling box shall house the winding temperature indicator (WTI, 150 mm dial), the oil temperature indicator (OTI, 150 mm dial), terminal block, 60W anti-condensation heater, 5/15A industrial type five pin socket and a 10W CFL with fixture, suitable for operating on 240 V AC. Contacts of Buchholz relay, WTI, OTI, magnetic level gauge, PRD, OSR shall be wired up to the terminal block.
- j) Noise level of transformers shall be as per latest NEMA standard.
- k) Oil - Transformers shall be supplied complete with transformer oil. Transformer oil shall be as per IS-335:1993, BS 148 or IEC 296. 10% extra oil shall be supplied with transformer in non returnable drums.
- l) Terminal Marking Plates and Rating Plates:

The transformers shall be provided with a plate showing the relative physical position of the terminal and their markings engraved on it. The transformers shall be provided with non detachable rating plate of Aluminium anodized material fitted in a visible position, furnishing the information as specified in IS: 2026. The rating plate

shall be embossed/engraved type. The relative position of tapping switch and corresponding voltages may also be shown on the rating plate. Further M.S. plate of size 125 mm X 125mm be got welded on width side of transformer on stiffener angle. On this plate, name of firm, orders No. and date, rating, serial No. and date of dispatch should be engraved.

j) Over load capacity:

The tenderer should state clearly the percentage overload the transformers can take for a continuous period of 1 hour. The transformers shall suitable for loading as per IS-6600/1972. The transformer shall be designed to obtain maximum efficiency at 75% load.

1.4.4.2 Maintenance Requirements For Transformers & Associated Equipment:

- a) The construction of the transformer & location of the accessories like CTs, lower ends of bushings, terminals, tap-changers etc., shall be such as to afford easy access & permit replacement of auxiliaries without removing the tank cover.
- b) Instruments & wiring in the local marshalling box (cabinet) shall be completely accessible & sufficient working space shall be made available in the cabinet. Instruments, wiring & accessories in the cabinet shall be accessible from the front & the rear as well.
- c) The rating plate of the transformer shall be supplied as per latest version of IS: 2026.
- d) Transformer shall be capable of being used with any make of transformer oil complying with IS: 335.
- e) As far as practicable, transformer & accessories shall be so designed that no special tools are necessary for installation & maintenance. However, if special tools are required, the Contractor shall supply one complete set of such tools along-with transformer.

1.4.4.3 Type Tests:

- f) The transformers offered should have been got type tested. The bidder will furnish Type Test Results. The following type tests must have been conducted on the material offered as per the relevant IS in NABL accredited laboratory as per the latest revision of the Technical Specification and the date of type test will not be later than 5 years.

1. Measurement of winding resistance (IS 2026 (part-I) :1977)
2. Measurement of voltage ratio and check of voltage vector relation ship (IS 2026 (part-I) :1977)
3. Measurement of Impedance voltage/short circuit impedance and load loss (IS 2026 (part-I) :1977)
4. Measurement of No Load loss and current (IS 2026 (part-I) :1977)
5. Measurement of Insulation resistance (IS 2026 (part-I) :1977)
6. Induced of over voltage with stand test (IS 2026 (part-3) :1981)
7. Separate source voltage withstand test (IS 2026 (part-3) :1981)
8. Impulse voltage test: (IS-2026 (Part-III)/1981- Voltage shall be 95KV peak

Insulation levels:

Sl. No	Voltage(KV)	Impulse voltage (KV Peak)	Power Frequency Voltage(KV)
1	0.433	-	3
2	11	95	28
3	22	125	50

9. Temperature rise tests (IS 2026 (part-II) :1977)
10. Short Circuit test (IS 2026 (part-I) :1977) (Dynamic & Thermal ability)
11. Air pressure test (IS-1180/Part-I/1989.)
12. Permissible flux density and over fluxing (IS-1180/Part-I/1989.)

1.4.4.4 Routine Tests/Acceptance Test:

- g. All transformers shall be subjected to routine tests at the manufacturer's works. The following routine tests shall be carried out in accordance with the details

specified in IS:1180 (Part-I) and IS:2026 or as agreed upon between the AP_PDCL and the manufacturer.

1. Measurement of winding resistance (IS 2026 (part-I) :1977)
2. Measurement of voltage ratio and check of voltage vector relation ship (IS 2026 (part-I) :1977)
3. Measurement of Impedance voltage/short circuit impendence and load loss (IS 2026 (part-I) :1977)
4. Measurement of No Load loss and current (IS 2026 (part-I) :1977)
5. Measurement of Insulation resistance (IS 2026 (part-I) :1977)
6. Measurement of Induced over voltage with stand test (IS 2026 (part-3) :1981)
7. Separate source voltage withstand test (IS 2026 (part-3) :1981)
8. Checking of weights, dimensions fitting and accessories, tank thickness, oil qty., material, finish and workmanship as per purchaser order and contract drawings.
9. Checking of di-electric strength of transformer oil
10. Load losses as specified in the specification.
11. Neutral current measurement – The value of zero sequence current in the neutral of

the star winding shall not be more than 2% of the full load current.

- g) In addition to the above tests, lightning impulse withstand test shall be carried out on one limb of HV winding of the transformer if impulse test has not been already carried out on transformer of similar or higher capacity in the last five years. Similarly heat run test shall also be carried out if the same has not been already carried out on transformer of similar or higher capacity in the last five years. Type test certificate shall be submitted along with the bid. if such a test has not been already carried out then same has to be carried out & witnessed by third party (such as CPRI) at the contractor's expense.

- h) All tests required by the specification including repeated tests and inspection that may be necessary owing to the failure to meet any tests specified, shall be carried out at the Contractor's expense.
- i) If the transformer fails to pass the tests specified, the Client shall have the option to reject the unit. Additional tests shall be conducted to locate the failure and after rectification, all tests shall be repeated to prove that the rebuilt transformer meets the specification in all respects, all at the Contractor's expense.
- j) The test certificates for all routine and latest (within 5 years) type tests for the transformers and also the bushing and transformer oil shall be submitted with tender.
- k) Unless otherwise specified herein the test value of the transformers supplied should be within the tolerance permitted in the IS 2026 on the guaranteed values. No positive tolerance shall be allowed on the maximum losses displayed on the label for both 50% and 100% loading values.
- l) BUSHINGS HT & LT: Tests as per ISS 2099/1962 shall be conducted on the transformer bushings as detailed below:
 - a) Dry flash over voltage
 - b) Wet flash over voltage
 - c) Dry 1Minute withstand voltage
 - d) Wet 1Minute withstand voltage
 - e) Impulse withstand voltage (1.2/50Micro seconds +ve wave)
 - f) Minimum oil immersed flashover voltage.
- Drawings/ Documents Required: Contractor shall submit the following drawings/ documents for Purchaser's approval:
 - a) General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of oil, crane lift for untanking, size of lifting lugs and eyes, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground etc

- b) Rating, diagram and terminal marking plates, complete with polarity and vector group
 - c) Foundation drawing with position of foundation bolts and depth. In case of Soak pit/ Burnt oil pit requirements, the same shall also be included.
 - d) General arrangement of HV cable box with air insulated disconnecting chamber.
 - e) General arrangement of LV Cable Box or Bus Duct arrangement.
 - f) General arrangement of marshalling box & wiring diagram.
 - g) General arrangement of OLTC/ RTCC & wiring diagram
 - h) GTP for Transformer.
 - i) Tender will have to produce documentary evidence for the purchase of CRGO sheet, Winding Copper Wire and Oil.
- Off Circuit Tap Changing Mechanism (OCTC) for Transformer <1000 KVA: OCTC shall be with + 5% to -10% taps in steps of 2.5 % on HV winding of transformer; It shall comprise:
- a) Operating handle or wheel, accessible from ground level. Tap changer operating switch mounted on the top of the transformer tanks will not be acceptable
 - b) Tap position indicator.
 - c) Pad locking arrangement without interfering with visual tap position indicator shall be provided.
 - d) The tap-changer connections and contacts shall be accessible through an excess hole having a bolted gasketed cover.
- On load Tap Changing Mechanism (OLTC) for Transformer ≥ 1000 KVA: OLTC shall be with + 5% to -15% taps in steps of 1.25 % on HV winding of transformer; It shall have following technical features:
- a) The OLTC gear shall be designed to complete successfully tap changes for current equal to 120% of current at minimum tap position of the transformer. Also, OLTC over loading capability shall be compatible with that of transformer specified in IS/IEC specification "Guide for loading of oil immersed transformers". 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.

- b) 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.
- c) 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.
- d) 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.
- e) Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection window with view glass.
- f) OLTC driving mechanism and its associated control equipment shall be mounted in an outdoor, weather proof 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:
 - i. Driving motor (415 V, 3 phase, 50 Hz, AC squirrel cage)
 - ii. Mechanically & electrically interlocked motor starting contactors with thermal overload relay, isolating switch and MCCBs.
 - iii. Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa will be provided in transformer marshalling box and one no. outgoing feeder extending to OLTC Driving Motor cabinet, with appropriate provision for receiving the same.
 - iv. Control switch: Raise/ off/ lower (spring return to normal type) or independent push buttons.

- v. Emergency 'OFF' push button (maintained type).
- vi. Remote/ local selector switch (maintained contact type).
- vii. Mechanical tap position indicator.
- viii. Limit switches to prevent motor over-travel in either direction or final mechanical stops.
- ix. Appropriate scheme/ device to permit only one tap change at a time on manual operation.
- x. Emergency manual operating device (hand crank or hand wheel).
- xi. A five digit operation counter.
- xii. Space heaters with thermostat and MCB.
- xiii. Control transformers with MPCB/ MCBs on primary and secondary sides for each supply.
- xiv. Interior lighting fixture with lamp, door switch/ ON-OFF switch and MCB.
- xv. Gasketted and hinged door with locking arrangement.
- xvi. Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
- xvii. Necessary relays, contactors, current transformers etc.
- xviii. Transducers or any other appropriate device for remote tap position indication.

g) Control Requirements for OLTC: The following electrical control features shall be provided:

- i. 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.
- ii. Only one tap change from each taps change command even if the command is maintained.

- iii. Cut-off of electrical control when manual operation is resorted to.
 - iv. 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.
 - v. Cut-off of electrical control when it tends to operate the tap beyond its extreme position.
- h) 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:
- i. Control switches; Raise/ Off/ Lower (spring return to normal type) or independent push buttons.
 - ii. If automatic operation is specified, auto / manual selector switch (maintained contact type) and other items as listed.
 - iii. If parallel operation is specified, master / independent / follower selector switch (maintained contact type) with 'out of step' annunciation.
 - iv. Tap position indicator.
 - v. Facia type alarm annunciators with "accept", "lamp test" facilities and hooter / buzzer for alarms as listed.
 - vi. Necessary auxiliary relays.
 - vii. Lamp indications for:
 - Tap change in progress
 - Lower limit reached
 - Upper limit reached
 - Transformer cooler control apparatus (if applicable)
 - vii. Cable glands for power and control cables.
 - viii. 240 V rated panel space heater with thermostat.
 - ix. CFL type interior lighting fixture with lamp and door switch.

- x. MCBs.
- xi. Terminal blocks.
- xii. Internal wiring.
- xiii. Earthing terminal.
- xiv. Hook up for the remote operation of tap lower and raise operation and contact/ signal for tap position indication to Purchaser's DCS shall be incorporated in the panel.
- i) Automatic Control of OLTC: Automatic voltage regulator (AVR) for auto control of OLTC shall include:
 - i. Voltage setting device
 - ii. Voltage sensing and voltage regulating devices
 - iii. Line drop compensator with adjustable R and X elements.
 - iv. Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
 - v. Adjustable dead band for voltage variation.
 - vi. Additional features as required when parallel operation with other transformers is specified.
- j) Alarms: The following alarms shall be provided:
 - i. A.C. supply failure
 - ii. Drive motor auto tripped
 - iii. Other protective purpose considered essential by the CONTRACTOR.
 - iv. Out of step operation when paralleled transformers supposed to operate on the same tap are operating at different taps.
 - v. Tap change delayed
 - vi. AVR failure (if AVR is specified)

vii. For the all specified above a “OLTC trouble” group alarm to be provided in DCS which is located in control room.

viii. Others, as specified.

k) TESTS:

i. Routine Tests: Routine tests as per IS: 8468 shall be performed on all OLTC's & Motor drive mechanisms. Over and above, Pressure and Vacuum tests shall be conducted as per IEC: 60214.

ii. Type Tests : Type tests as per IS: 8468 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. If type tests are not called for, type test reports for tests conducted (not older than 5 years) on a similar or higher rating OLTC & Motor drive mechanism shall be submitted for Purchaser's approval.

l) Additional Requirements, if any: Tap position indicators and OLTC control switch shall be supplied loose if purchaser decides to mount the same in the power transformer control panel.

m) The finish and dimensions of the panel shall be as specified so as

to match with the other panels in remote control room.

1.4.5 415 V LOW VOLTAGE METAL ENCLOSED SWITCH BOARDS :

1.4.5.1 Applicable Standards:

The design, manufacture and performance of equipment shall conform to the latest standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Metal enclosed switchgear : IS: 3427

General requirements

Factory Built Assemblies of SWGR : IS: 8623 / BS: 5486 / IEC: 439

and Control gear for Voltages up to

and including 1000V AC & 1200VAC

Air Break Switches : IS: 13947-P3 / BSEN6049 / IEC: 947-3

Miniature Circuit Breakers	: IS: 8828 / BSEN: 60898
Low Voltage Fuses	: IS: 13703 / BS: 1362 / IEC: 269-1
Contactors	: IS: 13947 / BSEN: 60947 4 / IEC: 947-1
Starters	: IS: 13947 / BSEN60947-4/ IEC: 292-1 To 4
Control Switches & Push buttons	: IS: 6857 / BSEN: 60947
Current Transformer	: IS: 2705 / BS: 7626
Voltage Transformer	: IS: 3156 / BS: 7625 / IEC: 44, 186
Indicating instruments	: IS: 1248 / BS: 89 / IEC: 51
Marking and Identification of	: IS: 11353 / BS: 159
Conductors and Apparatus	
Terminals	
A.C. Electricity Meters	: IS: 722, 8530 / BS: 5685 / IEC 145,211
Degree of Protection	: IS: 13947 / IEC: 947-P1
Selection installation and	: IS: 10118
maintenance of switchgear and	
control gear	
Code of practice for	: IS: 6005 / BS: 3189
phosphating iron and steel	
Specification for copper rods and	: IS: 613
bars for electrical purposes	
Control transformers for switchgear	: IS: 12021
and control gear voltage not	

exceeding 1000V AC

- Constructional Features: The switchgear shall be metal enclosed, modular type suitable for indoor/ outdoor installation, dust & vermin proof, self standing floor/ plinth mounting with a height not exceeding 2300 mm and shall have following features:

- a) Panels shall be complying to Form 4 as per IS 8623: 1993, Part I / IEC 439-1
- b) Breaker up to 1250A shall be installed in two tiers and above 1250A, it shall be mounted in single tier.
- c) Minimum clearance between live part shall be phase to phase 25.4 mm & phase to neutral 20 mm at any location & shall be complying with the BIL for the panel.
- d) Switchgear shall be divided into distinct vertical sections each comprising :
 - i. A completely enclosed bus bar compartment running horizontally.
 - ii. Enclosed vertical bus bars serving all modules in vertical section.
 - iii. A separate horizontal enclosure for all auxiliary power and control buses.
 - iv. Vertical cable alley of minimum 250 mm wide covering entire height
- e) Operating devices shall be incorporated only in the front of switchgear.
- f) Each shipping section shall have metal sheets at both ends
- g) Cable alley shall be provided with suitable hinged doors
- h) All doors shall be with concealed type hinges and captive screws
- i) Each vertical section shall be equipped with a space heater controlled by thermostat
- j) Each switchgear cubicle shall be provided with interior lighting with 11W CFL luminaries inclusive of lamp with door limit - on/ off switch.
- k) A 240 V AC, 5/ 15 A socket shall be provided in the interior of each cubicle with On-Off switch.
- l) All identical equipment and corresponding parts be fully interchangeable without any modifications
- m) Main and Auxiliary Buses:

- i. Switchgear bus bars shall be of uniform cross section throughout the length and made of Electric grade Aluminium (91 E – 63401)
- ii. All bus bars shall be covered with heat shrinkable black PVC sleeves. Coloured polyester tapes for phase identification shall be provided at suitable locations.
- iii. Bus bar shall be adequately supported to withstand stresses developed due to short circuits.
- iv. Bus bar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts, washers and nuts
- v. The exposed bus live parts in the cable alley shall be totally covered against accidental contact by a shroud (and not by sleeve) to protect the workmen working on the switchgear.
- vi. Vertical bus bars shall have Short Circuit rating same as main bus bar and shall be suitable for all connected load of vertical section.
- vii. Neutral bus bar size shall be 50% of phase bus bar.
- viii. Termination on bus bars at ACB, MCCBs shall be as per IEC60947-2. For terminations on MCCBs, where phase- phase and phase to earth clearance are not possible, Cu spreaders of suitable size shall be used along with the use of separators.
- ix. Bus bar supports shall only be SMC irrespective of bus bar size. The span between the two insulators shall be adequate. Joint positions and insulators shall be properly adjusted so that they don't interfere.
- x. For the Main PMCC, Contractor shall ensure that incoming feeders from transformer shall be suitably designed for terminating bus duct. Contractor shall consider the necessary arrangement (dummy panel, adapter panel, rear extension etc.) if required, for terminating the bus-duct. Phase transposition, if required, will be done in the Main PMCC.
- xi. Wherever Cu bus bars are provided, it shall be tinned copper & not bare Cu.
- n) All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the Contractor.

- o) All the indoor switchgear panels shall be suitable for IP-54 degree of ingress protection for the enclosure. Outdoor panels shall be with minimum IP-55, degree of protection
- p) All panels shall be made up of CRCA sheet steel of following thickness -
 - i. Load bearing members - 2.5 mm.
 - ii. Doors and partitions - Doors – 2 mm, Partition - 1.5 mm.
 - iii. Mounting plate - 2 mm.
 - iv. Gland plate - 3 mm for both incomer and outgoing. For single core cable these plates shall be non magnetic.
- q) All the panel wiring shall be done with PVC FRLS, multi-stranded copper wires
- r) Feeder shall have hinged open-able (more than 105°) type door with panel locks. All bus-bar covers and other panel covers shall be screw fixed.
- s) Suitable barriers of FRP material shall be provided between two terminals connected to different voltage supplies.
- t) All doors and detachable components shall be earthed with flexible green coloured (with Yellow coloured band) PVC sheathed 2.5/ 4.0 sqmm. multi-stranded Copper cable.
- u) The equipment shall be given tropical and fungicidal treatment.
- v) Each compartment & component shall be provided with name plates (with white letters on Black background) at front, inside & rear side.
- w) Equipment nameplates shall be fixed by screws/ rivets and shall not be pasted.
- x) Metallic Shrouding shall be provided for the isolation of main and vertical bus; as well as to avoid accidental contacts with live parts.
- y) Drawing pocket shall be provided on the inside of incomer feeder door.
- z) Provision for Top/ Bottom cable entry shall be made to suit the site condition.

- aa) Lifting hooks/ eyes shall be provided in each shipping section of the equipment and shall be removable type.
- bb) All the panels shall be provided with 20% extra power & control terminals.
- cc) All unused contacts of the circuit breaker, protection, auxiliary, control relays shall be wired up to the terminal block.
- dd) All terminals of different control voltages shall be separate from each other.
- ee) Stud type terminals and ring type lugs shall be used for control cables.
- ff) All the control/ power wiring shall be dressed neatly & the wire running through troughs shall be provided with covers
- gg) Switchgear shall be easily extensible on both sides by the addition of vertical sections after removing the end covers. It shall be provided with a metal sill frame made of structural steel channel section properly drilled for mounting the switchgear along with necessary mounting hardware. Hardware shall be zinc plated or passivated. It shall be provided with labels on the front and rear indicating the switchgear designation.
- hh) Any operating handle of switchgear shall not be more than 1800 mm and not lower than 300 mm from base of the panel.
- ii) For individual feeder modules arranged in multi tier formation, it is essential that the modules are integral multiples of the unit size to provide for flexibility in changes if any at site. For safety isolation of the vertical bus bars, insulating barrier with cut outs shall be provided to allow the power slab contacts to engage with vertical Bus bars. A vertical cable alley shall be sufficiently wide for motor control modules and for circuit breaker control modules.
- jj) A horizontal separate enclosure for all auxiliary power and control buses, as required shall be located so as to enable easy identification, maintenance and segregation from the main power buses. Tap off connections from these buses shall be arranged separately for each vertical section.
- kk) All equipment associated with a single circuit shall be housed in a separate module compartment of the vertical section.

- ll) For draw out type modules, only the handles of control and selector switches, push buttons, knobs & cut outs for lamps and meters shall be arranged on the front doors of the respective compartments to permit operation without opening the door.
- mm) On circuit breaker controlled circuits, protective relays shall be mounted on the front door of the compartment. All other equipment pertaining to a circuit shall be mounted on the withdrawal chassis. All cut outs shall be provided with gaskets for the purpose of dust proofing.
- nn) Current transformers shall not be directly mounted on the buses. Current transformer on circuit breaker controlled circuits shall be mounted on the fixed portion of the compartment.
- oo) In breaker compartments, external cable connections shall be carried out in separate cable compartments for power and control cables.
- pp) After isolation of the power and control connections of a circuit, it shall be possible to safely carry out maintenance in a compartment with the Bus bars and adjacent circuit live.
- qq) The withdrawals chassis shall move on suitable guides and on suitably plated steel or stainless steel rollers or balls to facilitate easy withdrawal.
- rr) Cable alleys shall be provided with suitable hinged doors. It shall be possible to safely carryout maintenance work on cable connections to any one circuit with the Bus bars and adjustment circuits live. Adequate number of slotted cable support arms shall be provided for cleating the cables.
- ss) Rear of single front switchgear shall be provided with removable panels. It shall be possible for one person to remove and fix the removable panel.
- tt) All doors shall be provided with concealed type hinges and captive screws.
- uu) The draw out contacts shall be only between copper/copper alloy/ aluminum fuses, which are silver or tinplated. The contact design shall be such that there should be no arcing/ deformation under the associated peak short circuit current.
- vv) Switchgear shall be designed in such a way that all components equipment and Bus bars operate satisfactorily without exceeding their respective maximum permissible rise in temperature under ambient temperature conditions prevailing

within the switchgear cubical, with reference to ambient temperature outside the switchgear cubical.

- ww) Provision of ventilating louvers shall be provided with fine-screened brass or GI meshes to prevent entry of vermin and dust.
- xx) The various types of modules indicating the control requirements of each type together with the list of component equipment required for each type shall be as follows: -
- i. Incoming circuit - Draw Out type air circuit breaker for above 630A/ Fixed type MCCB for 630A & below
 - ii. Outgoing feeder - ACB/ MCCB/ MPCB
 - iii. Auxiliary services - Starters, capacitors, Distribution Boards and other auxiliary load
- yy) Physical size of compartment for each type of control and current rating shall be so chosen that all the basic and additional equipment can be housed in the compartment. No equipment associated with any particular circuit shall be permitted to be mounted in any other circuit module.
- Power Distribution Board (PDB) configuration shall be two no. *A TPN MCCB I/Cs and six no. *A TPN MCCB O/G feeders. The O/G feeders shall be supplying to Sub DBs. The configuration of Sub Distribution Board (SDB) shall be *A FP MCCB I/C and 2 nos. 63A TPN MCB & 12 nos. 20A SP MCBs as outgoing feeders. (*A) shall be decided during detailed engineering.
- Separate instrument's compartment for indicators of flow meter (s), energy meter, level & pressure controller (if any) shall be provided as per actual requirement of suitable size.
- Voltages : Following control voltages shall be used in LV panels
- a) All ACBs tripping / Closing shall be suitable for 110/ 240V AC (24/ 110VDC) as applicable. The trip coil and closing coils of ACBs shall operate satisfactorily under the following conditions of supply voltage:
- i. Closing coils - 85 % to 110 % of rated voltage

- ii. Trip coils - 70 % to 110 % of rated voltage.
- b) Indications/ Annunciator for LV Main PCC/ MCC – 110/ 240V AC (24/ 110VDC)
- c) Indications for auxiliary DBs - 240V AC
- d) Space heater, 5/15A socket, panel illumination lamp etc. - 240V AC derived from AC bus
- e) 240V AC, 110V AC and other voltages shall be segregated to avoid mix-up of voltages.
- f) Control transformers suitably rated of voltage ratio 415/ 240/ 110 V on the Incomer/ Bus shall be provided. For the control transformers, fuses shall be provided on the 415 V side and MCBs on the 240/ 110V side. The control transformer shall be cast resin type only.

➤ Painting:

- a) All sheet steel work shall be paint through 7 tank electrostatic powder coating process in accordance with the required procedure and with the applicable standards. The switchgear enclosure shall be powder coated with shade as per RAL-7032.
- b) The final finished thickness of paint film on sheet steel enclosure shall not be less than 80 microns. Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces.

➤ Interchangeability:

All identical equipment and corresponding parts including chassis of draw out modules of the same size shall be fully interchangeable without having to carryout modifications. For trouble free interchangeability, the draw out arrangements shall be designed such that normal dimensional variations are taken care of by self-aligning feature of the modules.

➤ Drawings/ Documents Required:

Prior to fabrication of the switchgear, the contractor shall submit following for Purchaser Representative's approval - the dimensional drawing and design calculations indicating bus bar size, short circuit rating of all the electrical

component used, internal wiring, components mounting details etc. The contractor shall submit manufacturers catalogues of the electrical components installed in the switchgear.

➤ Inspection

At all reasonable times during production and prior to dispatch of the switchgear to site, the contractor shall arrange and provide all the facilities at their plant for inspection & testing of switchgear.

➤ Earthing

- a) Al/ GI earth bus bars of adequate size shall be provided for the entire length of the panel. The framework of the enclosure shall be connected to this earth bus. Provisions shall be made for connection from this earth bus to the main earthing bus bar coming from the earth pit on both side of the switchgear.
- b) The earth continuity conductor of each incoming and outgoing feeder shall be connected to this earth bus bar. The armour of cables shall be properly connected with earthing clamp and the clamp shall be ultimately bonded with the earth bus bar.

➤ Labels & Name Plate

- a) Engraved PVC labels shall be provided on all incoming and outgoing feeders. Single line circuit diagram showing the arrangements of circuit inside shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet.
- b) A nameplate with the switchgear designation in bold letters shall be fixed at top of the central panel. A separate nameplate giving feeder details shall be provided for each feeder module door.
- c) Inside the feeder compartments the electrical components, equipments, accessories like switchgear shall be provided with stickers shall suitably identify control gear, lamps, relays etc.
- d) Engraved nameplates shall preferably be of 3-ply (Red-White-Red or Black-White-Black) lamicoid sheet however black engraved perplex sheet nameplates shall also be acceptable. Engraving shall be done with square groove cutters.
- e) Nameplate shall be fastened by counter sunk screws and not by adhesives.

➤ Danger Notice Plates

- a) The danger notice plate shall be affixed in a permanent manner on operating side of the switchgear.
- b) The danger notice plate shall indicate danger notice in Gujarati, Hindi and English.
- c) The danger notice plate, in general shall meet to requirements of local inspecting authorities.
- d) Caution name plate, "Caution Live Terminal" shall be provided at all the points where the terminals are likely to remain live and isolation is possible only at remote end i.e. incomer to the switchboard.
- e) The danger notice plate shall be made from minimum 1.6 mm thick steel sheet and after due pretreatment to the plate, the same shall be painted white with vitreous enamel paint on both front and rear surface of the plate.
- f) The letters, figures, the conventional skull and bones shall be positioned on the plate as per recommendations of latest edition of IS 2551-1982.
- g) The said letters, the figures and the sign skull and bones shall be painted in signal Red color as per latest edition of IS 5 - 1978.
- h) The danger plate shall have rounded corners. Locations of fixing holes for the plate shall be decided to suit the design of the switchgear enclosure.

➤ Cable Entry:

- a) The panel shall have provisions of cable entry from top/ bottom. The removable cable gland plate shall be provided to make entry dust and vermin proof.
- b) The panel shall have provisions for fixing the multi-core cable glands.
- c) The cable glands support plates shall be 3 mm thick.
- d) Cable entries to the panel shall be from the bottom unless otherwise specified. Cable gland shall be double compression screwed type and made of brass.

➤ Mountings:

- a) All equipments in front of panel shall be of flush mounting type.

- b) All equipment shall be so mounted that the removal and replacement may be accomplished individually without interruption of services of others.
- c) All equipment inside the panel shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.
- d) The centerline of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise the top lines of all meters, relays and recorders etc. shall be matched.
- It is important to note that when pumping station is idle and transformer is required to be kept energized under no load/ part (miniscule) load condition, the necessary LT fixed capacitor bank (approx. 5% of transformer rating) shall be provided in PMCC (transformer LV incomer) panel and shall be manually/ automatically switched on to maintain power factor more than 0.95 but less than 0.99 (near unity). All the components for fixed type Capacitor bank (to be mounted in Main LV PMCC) panel shall be as indicated in typical electrical SLD attached with the specifications. This is a complete responsibility of the contractor to maintain the power factor under idle condition of pumping station. Any power factor adjustment charges levied by power utility shall be recovered from the contractor along with 5 % lump sum administrative charge by GUDC.
- Air Circuit Breaker (ACB)
 - a) All the incomers & bus coupler ACBs shall be FP EDO type. All other ACBs shall be TPN EDO type.
 - b) All the ACBs shall have $I_{cs}=I_{cu}=I_{cw}=100\%$
 - c) Up to and including 630 A, Fixed Type FP/ TPN MCCB shall be considered, while above 630A FP/ TPN fully draw out type ACB shall be considered in line with the electrical Single Line Diagram requirements.
 - d) All ACBs shall be provided with additional 6 NO + 6 NC contacts, exclusively for Purchaser's use.
 - e) All the ACBs (except for APFC panel) shall be provided with microprocessor based O/L+ S/C + inbuilt E/F protections.

- f) ACBs/ MCCBs for APFC panel shall be provided with thermal magnetic based O/L+ S/C + E/F protections.
- g) Each ACB shall be provided with – On, Off, Trip, Spring Charged, Trip Coil Healthy, Service & Test Position indication lamps.
- h) For incomer feeders R, Y & B Phase indication lamps shall be provided.
- i) All ACBs shall be Schneider make 'Masterpact NW' / Siemens '3WL' / L&T 'C Power' OR Equivalent from the approved make list.
- j) Circuit breaker shall be horizontal withdrawal type, comprising three/ four identical poles operated through a common shaft.
- k) It shall be suitable for switching duty of transformer and motors and other devices.
- l) It shall be possible to push in and withdraw the breaker easily and without much effort. Insulating plugs and sockets for power as well as for control circuits shall be of robust design and fully self-aligning. Plugs and sockets for power circuits shall be silver faced, insulated with PVC or other insulating material.
- m) The breaker shall have three distinct positions namely service, test and fully withdrawn positions. In test position, it shall be possible to operate the circuit breaker without energizing the power circuits. Separate limit switches each having a minimum of 4 NO contacts shall be provided for both service and test position of the circuit breaker. These contactors shall be rated for 10 Amp, 240 volts AC.

➤ Operating mechanism

- a) The EDO type ACB shall be power operated by a motor charged spring operated mechanism & MDO type shall be manual type spring operated mechanism.
- b) The operating mechanism shall have anti-pumping features under every method of closing. The operating mechanism shall normally be operated by LOCAL/ remote electrical control, when the breaker is in service position. Shunt trip coils shall perform electrical tripping.
- c) The main poles of the breaker shall operate simultaneously. Also there shall not be any objectionable rebound of the moving contact in the fixed contacts.

- d) The mechanism shall be such that any failure of auxiliary spring shall not prevent tripping. When the breaker is in closed position, failure of any auxiliary spring shall not cause damage to the CB or danger the operation.
- e) A mechanical indicator shall be provided on the breaker operating mechanism to indicate open and closed position of the breaker. This shall be visible to a man standing in front of the cubical with the door closed.
- f) It shall be possible to operate the breaker mechanically. This shall be possible only after opening the cubical door. Provision shall be made for local electrical control also when the breaker is in the test position by a control switch on the cubical doors.
- g) All working parts of the mechanism shall be of corrosion resistance material. All split pins; bolts, nuts and other parts shall be properly pinned and locked to prevent loosening with repeated operation of the breakers.
- h) Auxiliary switch containing 6 No. +6 NC potential free contacts rated for 10 Amp 240 V AC (Inductive breaking).

➤ Spring charged Mechanism

- a) Spring operated mechanism shall be complete with motor, opening spring, closing spring with limit switch for automatic charging and all necessary accessories to make the mechanism a complete operating unit.
- b) The breaker operation shall be independent of the motor, which shall be used only for tensioning/ compressing of the spring.
- c) The closing operation shall automatically charge the tripping spring. The closing, opening shall get charged immediately after a closing operation is performed.
- d) Motor used shall be preferably universal type operated on AC supply. The Motor shall operate satisfactory at all values “between” 85% to 110% of rated voltage.

➤ Mechanical / Electrical Interlocking:

- a) Mechanical interlock arrangement shall be provided between two incomer breakers. Interlocking arrangement shall be robust, heavy-duty type and sturdy in construction.

- b) Interlocking between two-incomer breakers shall be provided in such a way that in normal condition bus coupler shall be in “ OFF “ position so that both the transformer can be kept charged and the total load can be divided equally between two circuits.
- c) During fault, maintenance or any other abnormal condition while one of the transformer is not in working mode, the bus coupler shall be in “ ON “position so that total load can be supplied by the remaining transformer circuit.
- d) Interlock shall be Mechanical and Electrical type. In case if one of the interlock fails the other way can be used for interlocking purpose.

➤ Moulded Case Circuit Breakers (MCCB):

- a) The MCCBs shall conform to IEC 947 & the latest applicable standards.
- b) All MCCBs shall be of fixed type unless otherwise specified in the specifications elsewhere.
- c) MCCBs shall be of four pole/ triple pole with neutral construction arranged for simultaneous four/ three-pole manual closing and opening and for automatic instantaneous tripping on short circuit.
- d) All the incomer & bus coupler MCCBs for Main LT PMCC panels shall be FP type with microprocessor based O/L +S/C + inbuilt E/F release & all outgoings MCCBs shall be TPN with thermal magnetic based O/L +S/C + E/F releases.
- e) All MCCB's shall be Schneider make Compact NSX/ Siemens -Sentron 3VL OR equivalent from the approved make list.
- f) For achieving the Earth Fault protection in thermal magnetic (TM) based MCCBs, external CBCT, Earth Fault relay & shunt trip provision shall be considered as part of complete TM based MCCB.
- g) The ON, OFF and TRIP positions of the MCCB shall be clearly indicated by using LED indications.
- h) MCCBs shall be with ICS = ICU = 100%
- i) MCCB shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relay settings of the

motor starting equipment and the mechanical stresses caused by the peak short circuit current of value associated with the switch gear rating.

- j) All the MCCBs shall be of current limiting type and shall provide a cut off in 4-8 milli seconds for prospective currents during faults.
- k) All the MCCBs shall be provided with rotary operating handle with door interlock.
- l) MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.
- m) All MCCBs shall be provided with additional 2 NO + 2 NC contacts, exclusively for Purchaser's use.
- n) All the switchgear selection for motor feeders shall be Type-2 co-ordinated.
- Entire LV system shall be fuse less type & fuses shall be used only for PT/ Control Transformer primary side. MCBs shall be provided on secondary of PT/ Control transformer
- Miniature Circuit Breaker (MCB)
 - a) MCB shall be hand operated, air break, quick make, quick break type.
 - b) Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.
 - c) Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the characteristics of the connected load. Where this is not specified, it shall be Type C.
 - d) The short circuit rating shall be not less than that of the system to which they are connected.
- Direct-On-Line Starters: Direct on line motor starter shall have following components/ features:
 - a) Direct-on-line starters shall be suitable for Class AC 3 utilization category as per IS: 13947 (Part 4), unless otherwise mentioned in tender.

b) DOL starter shall have MCCB/ MPCB, Overload Relay with SPP, Contactor etc.

c) Type 2 Co-ordination shall be ensured.

➤ Automatic Star-Delta Starters: Automatic star-delta motor starters shall have following components/ features:

a) 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.

b) Star Delta Starters shall consist of MCCB/ MPCB, Overload Relay with SPP, Contactors, electronic timer etc.

c) 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.

d) Star-delta starters shall be suitable for AC 3 utilization category as per IS: 13947 (Part 4), unless otherwise mentioned in tender.

e) Type 2 Co-ordination shall be ensured.

➤ Reversing Starters: Motor Reversing starter shall have following components/ features:

a) Forward and reverse contactors, electrically interlocked with each other.

b) Reversing starters shall be suitable for Class AC 4 duty as specified in applicable standards, unless otherwise mentioned in tender.

➤ Auto Transformer Starter(ATS): Auto Transformer starter shall have following components/ features:

a) Auto transformer shall be air cooled type having 3 tapplings of 50%, 65% and 80%. The same should be wound with Copper wire. The size of the wire should be determined to suit the associated motor rating. The tapping requirement indicated is minimum required & Contractor to ensure proper tapping selection based on motor starting requirement.

- b) Stamping of reputed make and winding wire with 'B' class insulation should be used. This should also be suitable for minimum 6 starts per hour. Core shall be of CRGO material.
 - c) Maximum temperature rise should not be more than 115°C. Kordnoffer circuit (Closed Transition type) should be adopted in ATS panel. There shall be an acrylic / Hylam sheet over & below the transformer. Also to absorb humming rubber sheet shall be provided below auto transformer.
 - d) Auto transformer shall be vacuum impregnated.
 - e) Testing of transformers should withstand full load starting current for six starts per hour, each kick of 15 seconds duration as per relevant IS.
 - f) ATS shall be provided with thermal overheat protector in each coil of transformer from overheating. Thermal overheat protector rating shall be 900°C with 10% tolerance.
 - g) ATS shall consist of MCCB/ MPCB, Overload Relay, and Contactors etc.
- Soft Starters: Fully automatic microprocessor based soft starters with built-in bypass terminals for pump control application shall be considered for the motors above 110 kW. The features/ requirements of the starters shall be as per following but not limited to:
- a) The soft starter shall be designed, built and tested according to the latest editions of applicable IEC standards/ IEC 947-4-UL, CE.
 - b) Input Voltage - 3Ph, 415V, $\pm 10\%$
 - c) Input Frequency - 50 Hz, $\pm 5\%$
 - d) Control Voltage - 100 - 240 V AC
 - e) Ambient Conditions:
 - i. Temperature - 50 Deg C. (Operating range -5 to 70°C)
 - ii. Relative Humidity of 5 to 95%
 - f) Control Method - Torque Control/ Reduced Voltage/ Ramp
 - g) Motor Protection - Thermal overload protection

- h) Starter Protection – S/C, Phase imbalance, Phase failure, Phase reversal, O/ V, U/ V, Locked rotor, excessive starts per hour for application, Phase loss input/ output, Motor output loss.
- i) EMC standard – IEC 61000-4-2 level-3, IEC 61000-4-3 level-3
- j) Built-in communication port for RS 485.
- k) Type 2 Co-ordination shall be ensured.
- l) The soft starter shall be complete with the following acceleration and deceleration settings & display requirements as a minimum-
 - i. Starting Torque: Initial torque shall be adjustable from 0-100% of maximum locked rotor torque.
 - ii. Ramp Time: The time between starting torque and maximum torque shall be adjustable between 1 to 60 seconds. The time between maximum torque & stop shall be adjustable between 2 to 120 seconds
 - iii. The current limit feature shall have the following characteristics:
 - The maximum allowed current during start shall be adjustable from 150% to 500% of soft-starter maximum current rating.
 - Starting torque shall be fixed at 40% when utilizing the current limit function.
 - iv. Voltage Ramp start & Full voltage DOL start shall be possible.
 - v. For stop function – Linear torque control, Quadratic Torque Control, Voltage ramp control, soft break etc. functions shall be provided.
 - vi. The soft-starter shall be provided with a functional ground to remove and/ or minimize electrical noise injected on the soft starter control board.
 - vii. Normally open output relays shall be provided for faults and status indications.
 - viii. Normally closed contacts for fault relays shall be provided as an option.

- ix. The soft-starter shall be provided with a 2-position dip switch to select between the normal in-line connection (3-lead motor) and inside the delta (6-lead or 12-lead delta wound motors).
- x. The soft-starter shall be controlled completely through solid state design algorithms. No moving electromechanical contacts shall be allowed.
- xi. All adjustments shall be made from the front of the soft starter through keyboard (soft keys)
- xii. The Soft starter shall have remote display with following display parameters.
- Three Phase Currents
 - Three Phase Voltages
 - Shaft Power in kW / HP (selectable)
 - Motor thermal capacity
 - Motor Energy consumption (kWh)
 - Power factor
 - Run time in hours
- xiii. The Soft starter shall have following fault indications
- Line failure
 - Phase imbalance
 - Over temperature - Motor
 - Over temperature - Soft Starter
 - Shorted Thyristor
 - Open Thyristor
 - Locked Rotor
 - Motor output loss

- Overload - Shaft Torque
 - Underload - Shaft Torque
 - Over voltage
 - Under voltage
 - Excessive Starts
 - Phase reversal
- xiv. Shaft Power measurement without the use of external electro mechanical sensors.
- xv. Shaft overload and under load protection shall be available through the controller, even in a by-pass configuration.
- xvi. When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.
- xvii. The standard feature pump control shall be implemented to provide closed loop control of a motor to match the specific torque requirements of centrifugal pumps for both starting and stopping. This shall aid in eliminating the phenomenon commonly referred to as “water hammer”.
- xviii. The soft-starter shall be designed for three-phase control with two anti parallel SCRs in each phase. SCR-Diode combination shall not be acceptable.
- The PCB shall provide digital microprocessor control and supervision of all controller operation, including SCR pulse firing control.
 - The PCB power supply shall be self-tuning to accept control power input from 100 to 240 or 380 to 500 V AC, 50/ 60 Hz.
 - The SCR firing circuitry shall incorporate an RC snubber network to prevent false SCR firing.
 - When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.

xix. SCRs shall have the following minimum repetitive peak inverse voltage ratings:

- 200 to 525V: 1600 V
- 200 to 690V: 1800V

m) Soft Starter shall be ABB make PSTB 840-600-70/ Schneider make Alistart-48 or better from the approved make list.

➤ Variable Frequency drives: Variable Frequency system shall have provision such that inter-operability with instrumentation control system for flow control.

a) Applicable Standards

- i. Specification for metal clad base materials for printed circuits for use in electronic and telecommunication equipment - IS:5921
- ii. Specification of Transformers and Inductors (Power, Audio, Pulse and Switching) for Electronic Equipment-IS:6297
- iii. Semiconductor rectifier equipment safety code for IS:6619
- iv. Specification for printed wiring Board -IS:7405
- v. Recommended practice for emergency and standby power systems for industrial and commercial application- IEEE:446
- vi. Semiconductor devices -IS:3700
- vii. Basic climate for mechanical durability tests for electronic components-IS:9900
- viii. Environmental requirements of semiconductor devices and integrated circuits IS:6553
- ix. Ambient temp. of electronic Equipment-IS:9676
- x. Terminal for electronic equipment-IS:4007

b) Configuration

- i. Frequency drives shall have one of the two configurations given below suitable for induction Motor protection of all types confirming to IS 325 13947 (Part 4 /set 1) and 1993 / IEC 947-4-1 (1990)
 - Current source inverter.
 - Voltage source inverter.
 - Smoothing Reactors for Current and Voltage Source Inverter
 - ii. The smoothing reactor shall be sized to avoid conditions of discontinuous current
 - iii. Operation of the frequency converter at its lowest frequency of operation, which shall not be less than 5 Hz.
 - iv. The smoothing reactor shall be uniformly insulated and shall be protected for voltage surges occurring during sudden load throw-off.
 - v. The smoothing reactor shall be made from electrolytic grade copper/aluminum and shall be epoxy encapsulated with suitable class of resin decided from techno-economic considerations and performance requirements in conformity with IEC-146.
- c) Inverter: The inverter system suitable for three phase output shall consist of the following subsystems:
- i. The basic inverter circuit consisting of the switching device say Thyristors / Transistors/IGBT/MOSFET, connected so as to supply three phase power.
 - ii. The logic network to enable rapid transition of the main inverter switching devices from on-state to off-state.

- iii. Suitable feedback system to allow balance of reactive power flow during load power factor fluctuation as well as regeneration.
- iv. The filter system of the inverter output to suppress 5th, 7th, 11th, 13th harmonics at the output of the inverter to less than 5% of the fundamental amplitude.
- v. The ripple control system to limit current ripple to 4% at the input terminals of the inverter caused by distorted current output.
- vi. The output frequency of inverter shall be controlled to within the limits.

d) Inverter for AC Drive

Current Source Inverter:

Constant Torque Operation

The current output by the DC link shall be accurately monitored so that the ratio of the terminal voltage of the motor and the corresponding frequency remains constant. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

Constant Horsepower Operation

In this type of operation, the motor's internal voltage shall be maintained within + 1% while the frequency of the inverter is varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

Voltage source Inverter:

Constant Torque Operation

The DC voltage input to the inverter shall be accurately monitored to maintain the ratio the terminal voltage of the motor to frequency at the rated/design value. The DC voltage input shall be maintained within + 1% of the required value. Should this fall for any reason, necessary action for tripping the frequency converter and initiation of annunciation/alarm and fault diagnostic shall be provided.

Constant Horsepower Operation

In this type of operation, the voltage at the terminals of the motor shall be maintained within +1% of the rated value while the frequency of the inverter is varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, initiation of alarm/annunciation and fault diagnostic shall be provided.

Output Over current Limit:

Unless otherwise stated, the inverter shall be capable of being temporarily overloaded to 150% of its full load ampere capacity for sixty (60) seconds beyond which a current limit action shall be initiated and an alarm contact initiated for annunciation.

Control Modules

All elements of the control system shall be mounted on epoxy laminate boards and each board shall be a plug in module mounted on a standard nineteen inch rack which shall be accessible from the front. Each card shall have LED indication on its front plate to indicate normal condition of the card. Readily accessible and clearly marked test pins shall be provided at the important points on the cards to enable signal analysis.

The epoxy laminates shall be free from manufacturing errors and shall be designed to prevent incorrect insertion in the card rack. The copper side of the card shall be suitably lacquered to prevent oxidation. The gap between two cards shall be sufficient to permit adequate ventilation.

Adjustments susceptible to change by accidental contact shall be lockable.

e) Control Requirements:

Short time voltage dips up to 80% of nominal (e.g. in case of large motor start-up connected to same bus) shall not cause the control system to stop functioning and shall not trip the drive system.

The drive motor shall be speed regulated corresponding to 4-20mA or 0-10V reference input signal. Upon complete loss of users speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to loss of the signal.

The required provision for interfacing with PLC/DCS, including details of communication module and data transfer facility, I/O details shall be furnished by the Bidder.

f) Protection

Protection of Power Semiconductor

Each power semiconductor shall be protected against short circuit. The fuse shall be sized so that its I^2t does not exceed the I^2t characteristic of the power semiconductor itself. The voltage and current rating of the fuse shall match the duty on the power semiconductor. The arc voltage, due to melting of the fuse shall not exceed the repetitive peak reverse voltage of the power semiconductor.

All fuses shall have a trip indicator to operate a suitable micro switch with at least 1 NO + 1 NC potential free contacts for annunciation and/or tripping.

A fast tripping feeder circuit breaker shall be used in case fuses for short circuit protection of thyristors are not used.

g) Protective Systems for AC Inverter Drive

Fuses for all power semiconductors and/or other devices like commutation chokes, capacitors etc. which are not adequately protected against flow of abnormal currents.

Under voltage and over voltage protection on the input side. Loss of input voltage to inverter shall entail tripping of the inverter.

Protection for all control cards, power supply stabilizers, filter circuits etc. Protection shall be provided such that failure of a part does not cause damage elsewhere in the system.

Polarizing relay to prevent reversal of polarity on the input side of the inverter.
Protection of inverter thyristor, commutating circuits and other inverter elements during regenerative operation of the inverter and also during sudden load throw-off.

Current limit fuses at the output of the inverter.

Commutation circuit under voltage

Inverter over frequency

Programmable over current

Phase sequence/loss of phase protection

Earth fault protection

DC link overvoltage protection

Specific motor protection

Incoming line surge protection

Ventilation Loss

Over temperature

h) Cooling of Power Converters

Power semiconductors shall be mounted on heat sink which can be individual or common to a number of devices. Adequate provision for clamping and mounting the power semiconductors shall be available.

Cooling of power semiconductors can either be natural air cooled or forced air cooled. The BIDDER shall recommend the type of cooling. However, for power converters which exceed capacities of 2 kA continuous load, alternative cooling methods as oil or water cooling shall be considered. The power semiconductors shall preferably be double side cooled.

i) Switching Devices

Switching devices such as circuit breakers, isolators, contactors; switch-fuse units etc. shall be considered in the scope of supply.

The switching devices shall be enclosed in a separate enclosure forming the set of panels for the power converters. They shall have adequate clearance both with adjacent devices and metalwork at earth potential. Connection between devices shall be by adequate size of electrolytic grade of copper/aluminum strips. These connections shall be adequately braced and insulated.

➤ Contactors: The power contactors used in switchboard shall have following features:

- a) The contactors shall confirm to IS 13947 & the latest applicable standards
- b) The power contactors shall be of, air break, single throw, triple pole, electromagnetic type.
- c) The insulation class of contactor's coil should be B or higher.
- d) Operating coils of all contactors shall be suitable for operation on 110/240 V, single phase, 50 Hz supply.
- e) Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts.
- f) Contactors shall not drop out at voltages down to 70 % of coil rated voltage.
- g) All the switchgear selection for motor feeders shall be Type-2 co-ordinated.
- h) Motor starters shall be complete with auxiliary relays, timers and necessary indications.

➤ Relays:

- a) Main protective relays shall be Numerical type. They shall be suitable for semi-flush mounting with only flanges projecting on the front with connections from the rear.
- b) All relays shall be enclosed in rectangular shaped, dustproof cases and shall be suitable for flush mounting.
- c) All protective relays shall be in draw out cases with built in test facilities.

- d) Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage
 - e) Test block and switches shall be located just below each relay for testing unless otherwise specified. All auxiliary relay and timers shall be supplied in non-draw out cases.
 - f) All protective relays shall be provided with at least two pair of potential free output contacts, exclusively for Purchaser's use.
 - g) Relay cases shall have adequate number of terminals for making potential free connections, to the relay coils and spare contacts. Paralleling of contacts if any shall be done at the terminals on the casing of the relay.
 - h) Each relay shall have provision for easy isolation of trip circuit for the purpose of testing and maintenance.
 - i) All relays shall with stand out a test voltage of 2 KV, 50 Hz RMS voltages for one minute.
 - j) Auxiliary seal in units provided on the protective relay shall be shunt reinforcement type.
 - k) 132 kW & above rated motors shall be breaker controlled with motor protection relay Siemens '7SK 80' OR equivalent from approved make list.
- Thermal Overload Relays:
- a) Starters shall be complete with a three element, positive acting, ambient temperature compensated, time lagged thermal overload relay with adjustable settings. The setting range shall be properly selected in accordance with the rating of the motor.
 - b) Thermal overload relays shall be hand reset type
 - c) 'Stop' push button of the starter and hand-reset device shall be separate from each other.
 - d) Overload relay hand reset push button shall be brought out on the front of the compartment door. Overload relay shall be provided with at least 1 'NO' and 1 'NC' or one changeover contact.
- Timers:
-

Thermal/ Electronics timer for change over in star-delta and ATS panel should be provided.

➤ Switch And Contactor Ratings

Switch and contactor rating for various motor starter modules shall be selected by the Contractor, based on the specifications. CONTRACTOR shall also select appropriate ratings & ranges for thermal overload relays. These details shall be subject to the Purchaser's approval.

➤ Single Phasing Preventers:

- a) Single phasing preventer relay shall be provided to protect motors against single phasing.
- b) It should operate satisfactory from 320/ 480V. Timing range of delay start 0 - 45 seconds.
- c) Toggle switch for Auto SPP by pass should be provided on front of unit.
- d) The relay shall not operate for supply voltage unbalance of $\pm 5\%$. After sensing single phasing, the relay shall operate with a time delay of 2 to 3 secs.
- e) The relay shall not operate for a 3- phase power supply failure. The relay shall be of the hand-reset type with a hand-reset push button. Resetting shall be instantaneous and independent of the adjusted time delay in the tripping of the unit. Visual indication for the operation of the relay shall be provided.
- f) The relay shall be suitable for application to protect reversible and non reversible motors.
- g) The relay operation shall be independent of the motor KW rating, the loading conditions prior to the occurrence of the single phasing and RPM of the motor.
- h) The relay shall be of the fail-safe type and shall operate to trip the motor when the relay internal wiring is accidentally open circuited.

➤ Power & Control Wiring Connections:

- a) Terminals for both incoming and outgoing cable connections shall be suitable for 1.1kV grade Al/ Cu conductor XLPE armoured cable and shall be suitable for connections of solder less sockets for the cable size.

- b) Main PMCC incomer feeder shall be suitable for bus duct connections using Aluminum Bus bars
- c) Both control and power wiring shall be suitable for Bus Duct / Cable termination as per guidelines mentioned in transformer specifications.
- d) Both control and power terminals shall be properly shrouded. Power terminals shall be of stud type.
- e) 20 % spare terminals shall be provided on each terminal block. Sufficient terminals shall be provided on each terminal block so that not more than one out going wire is connected to per terminal.
- f) Suitable barriers of enclosures shall preferably separate terminals strips for power and control from each other.
- g) Wiring inside the modules for power, control, protection and instruments etc shall be done with use of 1.1 kV grade, multistranded Cu, PVC FRLS wiring.
- h) Power wiring inside the starter module shall be rated for full current rating of respective contactor but not less than 4 Sq. mm. 2.5 Sq. mm copper wire shall be used for current transformer circuits.
- i) Other control wiring shall be done with 1.5 Sq. mm copper conductor wires.
- j) Wires for connection to the door shall be flexible. All conductors shall be crimped with solder less sockets at the ends before connections are made to the terminals.
- k) There shall be control transformer for control power supply (110/ 240V AC) and separate control bus.
- l) Particular care shall be taken to ensure that the layout of wirings is neat and orderly. Identification ferrules shall be fitted to all the wirings terminations for ease of identification and to facilitate checking and testing.
- m) Washers shall be used for all Copper and Aluminum connections.
- n) Final wiring diagram of power and control circuit with ferrules nos. shall be submitted along with the panel as one of the documents against the contract.

➤ Terminals:

- a) The outgoing terminals and neutral shall be brought to a cable alley suitably located and accessible from the panel front.
- b) The current transformer for instruments metering shall be mounted on the disconnecting type terminal blocks. No direct connection of incoming or outgoing cables to internal components of the distribution board is permitted; only one conductor may be connected in one terminal.

➤ Wire Ways:

- a) The horizontal PVC wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical sections.

➤ Indicating Instruments:

- a) All electrical indicating instruments shall be rectangular, Analogue type meter shall have 240 degree scale, taut band, minimum 144 x 144 mm size unless specified otherwise, moving coil instruments, suitable for semi flush mounting with only flange projecting on vertical panels.
- b) Ammeters for motor feeders shall have suppressed scale up to 6 times beyond full load.
- c) Dials shall be parallax free and white with black numbers and letterings & pointer shall be of knife-edge type. Such instruments shall be provided with zero adjustor accessible from the front.
- d) Instruments shall have an accuracy class 1.0 or better.
- e) Instrument dials shall be white with black numbers and lettering.
- f) Ammeter and current coils of wattmeter's and ammeters shall continuously withstand 120 % of rated current and 10 times the rated current for 0.5 second without loss of accuracy.
- g) Voltmeters and potential coils of voltmeters shall withstand 120 % rated voltage continuously and twice the rated voltage for 0.5 seconds without loss of accuracy.

➤ Metering Instruments:

a) Multifunction meters shall be provided for all the feeders of 250A & above. For balance all feeders, kWh meters shall be provided. Size of the MFM shall be 96 x 96 sq. mm. MFM shall be provided with following metering features:

- i. Current, Voltage, Energy (kWh), MD (kW, kVA), PF & Hz etc.
- ii. MFM shall be L&T make 'Quasar' / Siemens OR equivalent.
- iii. MFM shall be with accuracy class 1.0 or better & having RS 485 communication port.

b) Watt-hour meters shall be of 3-phase two- element type suitable for measurement of unbalanced loads in three phases, three wire circuits. They shall be suitable for semi flush mounting on vertical panels.

c) Watt hour meters shall be of the induction type and shall be provided with reverse running stops.

d) Watt-hour meters shall be suitable for operation from the secondary of CTs and PTs. They shall be provided with a separate 3 phases, 4 wires type test terminal blocks for testing of meters without disturbing CT and PT secondary connections.

e) Meters shall be provided with potential indicating lamps and shall have reverse running stops.

f) Meters shall have pointer as well as cyclometer type of register. They shall read KWH, KVARH, and PF as the case may be without the use of multiplication factor which, if unavoidable, shall be 10. The number of digits provided shall be adequate to cover 1000 hours of operation.

g) Current coils of meters shall have a continuous overload capacity of 120 % for both accuracy as well as thermal limits. Also the coil shall withstand at least 10 times rated current for 0.5 second without loss of accuracy.

➤ Current Transformers:

a) Current transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.

b) Current transformer shall have a short time withstand rating equal to the short time withstand rating of the associated switchgear for one second for breaker feeders.

- c) Unless otherwise specified, the minimum performance requirement of current transformers is as follows:
- d) Measuring CTs -15VA, accuracy class 1.0 and.
- e) Protective CTs - 15 VA, accuracy class 5P20.
- f) The above mentioned burdens are minimum required & it will be Contractor's responsibility to coordinate the current transformer burden with the requirements of relays, instruments and leads associated with that particular current transformer. Contractor has to provide sufficiency calculations for the same.
- g) Current transformer (CT) shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block
- h) CT shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit current
- i) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests.
- j) Identification labels giving type, ratio, output and serial numbers shall be provided.

➤ Voltage Transformers:

- a) Voltage transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.
- b) Unless otherwise specified, the minimum performance requirements of Voltage transformers are as follows:
 - i. Measuring VTs - 50 VA per phase and accuracy class 1.0
 - ii. Protective VTs - 50 VA per phase and accuracy class 3.0.
 - iii. Dual purpose VTs - 100 VA and dual accuracy class 1.0/ 3P for metering and protection respectively. VA is per phase.
 - iv. The above mentioned burdens are minimum required & Contractor has to provide sufficiency calculations for the same.
- c) All secondary windings of voltage transformers including open delta windings shall be rated for $110\sqrt{3}$ V, 110V/ 3 per phase.

- d) Voltage transformer shall have a continuous over voltage factor of 1.2 and short time over voltage factor as follows:
 - i. 1.5 for 30 seconds in case of effectively earthed system.
 - ii. 1.9 for 8 hours in case of non-effectively earthed system.
- e) Voltage transformers shall be complete with suitable rated primary, fuses. Primary fuses shall have a rupturing capacity equal to the rupturing capacity rating of the associated switchgear. All the secondary circuits of the PT shall be protected by MCBs.
- f) It shall be possible to replace voltage transformers without having to de-energize the main bus bars.
- g) The terminals of PT secondary and tertiary windings, which are required to be connected to earth, shall be earthed by an isolating link without a fuse.
- h) Identification labels giving type, ratio, output and serial numbers shall be provided.

➤ Push Buttons:

- a) Push buttons shall have two normally open and two normally closed contacts unless otherwise specified. The contacts shall be able to make and carry 5A at 110V DC and shall be capable of breaking 1A inductive load at 110V DC. They shall be provided with inscription plates engraved with their functions.
- b) Emergency stop' push buttons shall be of Mushroom type, lockable in the pushed position and shall be shrouded to prevent accidental operation. Key shall not be required for the operation of the push button.
- c) The Internal wiring and terminal blocks shall meet the relevant requirements.

➤ Auxiliary Transformers:

Any auxiliary voltage required for any of the component inside the switchgear shall be derived from the main supply by providing adequately rated auxiliary transformer mounted inside.

➤ Indicating Lamps: Indicating lamps shall be:

- a) Clustered LED type and of low watt consumption.

- b) Provided with series resistors.
- c) Provided with translucent lamp covers of colors 'Red', 'Green' and Amber' etc. as required.
- d) Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 110 V AC or at the specified AC/ DC system voltage as applicable.
- Control & Selector Switches: Control and selector switches shall be:
 - a) Rotary type with enclosed contacts.
 - b) Adequately rated for the purpose intended (Minimum acceptable rating is 10A continuous at 230V AC and 1A (inductive break) 220V D.C.
 - c) Provided with escutcheon plates clearly marked to show the positions.
 - d) Control switches shall be spring return to normal type & provided with pistol grip type handles.
 - e) Selector switches shall be maintained contact stay put type. Switches in ammeter circuits shall be of break type contact. Selector switches shall be provided with oval handles.
- Space Heaters:
 - a) Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk.
 - b) Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system.
 - c) Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 350 C.
 - d) Space heater indicated in the breaker modules represents the space heater for each vertical section of the switchboard. Where breakers are mounted in two-tier formation, then only one space heater with associated MCB and thermostat is adequate for the vertical section
- Cubicle Lighting / Receptacle:

- a) Each control cabinet, marshalling box, etc. shall be provided with interior lighting by means of 11 W CFL luminaries with door operated On/ Off switch.
- b) A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with a MCB.
- Routine and Acceptance Tests to be conducted by the manufacturer at their own risk and cost in presence of Purchaser/ Purchaser's representative during inspection & testing at manufacturer's works:
 - a) Following Routine tests as per IS: 13947 and IEC: 60947 standards & other specified relevant IS standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's representative on LV Switchgear panel complete with the accessories.
 - i. Dielectric test on main circuit.
 - ii. Test on auxiliary and control circuit.
 - iii. Measurement of insulation resistance of the main circuit.
 - iv. Tightness of main circuit.
 - v. Design and visual check.
 - vi. Dimensional check and BOM verification.
 - vii. High Voltage test on power & control circuit.
 - viii. Functional & mechanical operation test of all components.
 - ix. Measurement of thickness of sheet steel & paint.
 - x. Verification of wiring as per approved schematic.
 - b) Following Type Tests reports as per IS: 13947 and IEC: 60947 to be submitted for the same rating & type of LV Switchgear panel conducted in past for review of Purchaser at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.
 - i. Dielectric test on main and auxiliary circuit.
 - ii. Temperature rise test.

iii. Making and Breaking test of switching elements.

iv. Degree of protection test.

v. Short circuit withstand test.

vi. Electromagnetic compatibility test.

c) Certified copies of all type and routine test certificates and Calibration Certificates of measurement instruments which are used during inspection shall be submitted for the Purchaser's review/ approval before dispatch of the switchgear.

➤ Test Certificates:

a) Testing of switchgear shall be carried out at factory or at site as per standard in presence of Purchaser/ Purchaser's representative.

b) The test results shall be recorded on prescribed forms. The certificates for the test carried out at factory or at site shall be submitted in duplicate to the Purchaser/ Purchaser's Representative for approval. Components and equipment that are not fully interchangeable are liable for rejection. Contractor shall replace all such non interchangeable equipment at his cost.

➤ Drawings/ Documents Required: After award of contract Contactor has to submit drawings/ documents for Purchaser's approval as mentioned below but not limited to:

a) General arrangement diagram showing dimensions of enclosure, length, widths and depth of enclosure and bill of quantity indicating the rating, make of each components and quantity.

b) Complete assembly drawings of the switchboard/ distribution board/ MCC showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections, etc.

c) Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.

d) Schematic power and control wiring diagrams with bus bar rating with material, instrument & control transformers, switchgear rating, control interlocks, relays, instruments, space heaters details etc.

1.4.6 LOCAL PUSH BUTTON STATIONS:

- Constructional Features: The constructional features of the local push button stations shall be as follows:
- a) Metal enclosed, weatherproof, suitable for mounting on wall or steel structures. The enclosure shall be die cast aluminum or sheet metal of 2 mm thickness.
 - b) Dust and vermin proof.
 - c) Provide a degree of protection of not less than IP55.
 - d) Metal parts shall be given tropicalising treatment as per standards and painted with one coat of epoxy primer and two coats of light gray epoxy paint.
 - e) Provided with inscription plates of rear engraved Perspex with white letters on black background. The letter size shall be 6 mm.
 - f) Provided with two earthing terminals suitable for earthing wire /strip.
 - g) Provided with removable undrilled gland plate and cable glands for two nos. 5C x 2.5 mm² Copper conductor, XLPE insulated, armoured cable. The cable entry shall be from the bottom.
 - h) Earthing shall be provided by 8 SWG GI wire and connected to earthing system.

1.4.7 APFC PANEL WITH CAPACITOR BANKS:

- Scope of this specification covers 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, unloading, storage at site, assembly, erection, testing, installation, commissioning and performance demonstration of the following equipment with associated accessories.
- Capacitor Banks:
- a) The type of capacitors shall be All Polypropylene type double layer conforming to IS 13585 - 1994 & having following specifications:

Supply	3 phase, 3 wire
Rated voltage	415 V

Rated frequency	50 Hz.
Permissible over voltage	1.1 Vn
Permissible over current:	1.5 In
Temperature category:	50° C

- b) The capacitor shall be vacuum impregnated with liquid dielectric having high thermal stability.
- c) The capacitors shall have Low Dielectric Loss of $\leq 0.5 \text{ W / kVAR}$.
- d) Each capacitor bank shall be provided with the 7% detuned filter.
- e) * kVAR is net reactive compensation required to maintain 0.99 PF at 415 V Bus, i.e. excluding compensation required for detuned filters.
- f) Bushing should have high mechanical strength & method of fixing should be proper so that no leakage occurs.
- g) Auto/ Manual switch shall be provided in the APFC panel. For manual switching, every capacitor bank feeder shall be provided with ON & OFF push buttons along with the ON & OFF indications.
- h) Minimum current rating under site conditions, of circuit breakers, contactors and cables shall be at least 150% of rated capacitor current, to take care of harmonics.
- i) Contactor for switching of capacitor banks shall have AC -6b utilization category according to IEC 60947-4-1 & sized accordingly.
- j) All the components shall be suitable for capacitor duty application.
- k) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not. Capacitor shall be designed to improve the power factor to 0.99 lagging

- l) It shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, Al/ Cu bus bars, Al/Cu connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.
 - m) The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units. The assembly of the banks shall be such that it provides sufficient ventilation for each unit.
 - n) Each capacitor case and the cubicle shall be earthed to a separate earth bus.
 - o) Capacitor shall conform to IS 2834.
 - p) The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10 % above the rated voltage, excluding transients.
 - q) Each capacitor unit/ bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute upon disconnection, in accordance with the provisions of the latest edition of IS:2834.
- Control Cubicles:
- a) Capacitor and capacitor control shall be housed in a metal enclosed cubicle. Capacitor shall be housed in the lower compartment and capacitor control unit at the top compartment, the two compartments being segregated. Control cabinets shall be free standing floor mounted type and shall meet the requirements of Metering, Protection & related provisions for APFC panel as tabulated below:

Panel Name	Breaker Type	Protection	Metering	Indications	Other
APFC Panel					
Incomer	ACB (TPN, MDO) OR MCCB (TPN, Fixed Type)	TM based O/L, S/C release, APFC Relay, E/F Relay with CBCT & Shunt Trip	Analogue A,V	R Y B, On, Off, Trip	ETPB, A/M SS, Annunciator
Outgoing	MCCB (TP, Fixed Type)	TM based O/L, S/C release	A, AS	On, Off, Trip	Start, Stop Push Buttons

- b) APFC panel shall have AI bus bars sized for appropriate SC rating for 1 sec & to carry continuous rated current.
- c) All CTs / PTs shall be cast resin type.
- d) All the MCCB's shall be current limiting type. Necessary auxiliary contact block required is included in contractor scope.
- e) One contact of power factor correction relay shall be provided for annunciation "POWER FACTOR LOW". The relay shall switch-on / off capacitor banks for loads from 5% to 100%. The annunciation window shall be with test, accept and reset push button & hooter.
- f) Capacitor switching and automatic power factor correction panel shall be designed in such a way that power factor of 0.98 lagging shall always be maintained. Timings to cut in capacitors shall be provided in such a manner to facilitate capacitor discharging before next switching and shall also avoid hunting due to temporary fluctuations of load. The timer shall be provided in both auto and manual mode.
- g) The Automatic power factor correction panel and capacitor panel are integral type, prewired including power connections. Due consideration shall be given for adding/removal of capacitor or other components and maintenance considerations.

Contractor shall submit GA drawings of capacitor and capacitor control panel, with description of power factor control panel with its components.

- h) For control circuit 415/ 240/ 110V control transformer shall be considered. VA burden to be decided by the Contractor.
- i) Minimum clearance between live parts shall be phase to phase 25.4 mm & phase to neutral 20 mm.
- j) Bus bars shall be sleeved with coloured heat shrinkable sleeves. All the Bus bar supports shall be SMC type only.
- k) Degree of protection shall be IP-42 for the enclosure, epoxy painted, powder coated with colour shade RAL- 7032 for exterior & interior with minimum thickness 80 micron.
- l) All necessary auxiliary contactors are included in scope.
- m) Contractor shall note that verification of double layer construction shall be done on any one of the capacitor bank during inspection by opening the capacitor bank at no extra cost.
- n) The cubicle shall be fabricated out of 2 mm thick cold rolled sheet steel & shall comprise of :
 - i. Isolating ACB / MCCB
 - ii. Contactors with overload element
 - iii. Sequencing devices, timers and auxiliary relays for automatic sequential switching of capacitor units in and out of circuit.
 - iv. Auto-manual selector switch
 - v. Microprocessor based Automatic Power Factor Correction (APFC) Relay – minimum 10 stage relays.
 - vi. Push button for opening and closing the power circuit
 - vii. Red and Green lamps for capacitors ON/OFF indication
 - viii. Protective relays to protect the healthy capacitor units when one unit fails in a series connection

ix. Space heater and cubicle lighting & receptacles.

x.

- Principle of Operation On deviations from set power factor, the power factor controller shall release command signals to switch on/ switch off capacitor bank stages and maintain the set power factor.
- APFC Relay: APFC relay shall have following standard features:
 - a) The Automatic Power Factor Correction relay shall be of microprocessor based type and shall automatically switch ON/OFF the capacitor banks to attain the value of “pf” close to the set value.
 - b) Switching shall follow first in first out (FIFO) method to ensure uniform use of all capacitor banks. At least eight steps shall be provided for switching.
 - c) To measure/ monitor power factor and VAR continuously. Status of switching step shall be displayed through LED.
 - d) Following adjustment shall be available in APFC Relay.
 - i. Power factor
 - ii. Dead band capacitive region with respect to set power factor (PF).
 - iii. Inductive region with respect to set PF
 - iv. Operating time for programmable switching steps.
 - v. Auto/ manual selector switch.
 - vi. Manual step control.
 - e) All control knobs, LEDs for display and selector switches shall be mounted on the front face of relay casing/ panel.
 - f) It should be fully programmable. There should be a choice for customer to select operating sequence up to 4 to 5 which will have maximum number of steps of capacitors equal to fourteen (14). The sequence shall be arithmetic 1, 2, 3.....13, 14.

- g) 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 sec. has elapsed so that it has safely discharged. This is a requirement for 415 V capacitors
- h) Loss of voltage element. This would prevent abnormal switching surges on loss of supply. Also it would control the switching on/off surges.
- i) Dead band features – Relay response sensitivity adjustable using dead band so that hunting is prevented.
- j) Auto/Manual control – This would help testing and commissioning at site as well as ease in operation when either mode fails during service time.

➤ Performance Tests:

- a) Contractor 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, Contractor shall conduct the necessary type tests in the presence of Purchaser/ Purchaser's representative.
- b) Contractor shall also carry out all routine and functional tests as specified in the relevant IS on the assembled switchgear panels in the presence of the Purchaser's representative at works before dispatch and furnish copies of test reports for approval. If required stage inspection will be carried out by the Purchaser.
- c) During inspection, Contractor shall furnish copies of routine test report for all bought out items for Purchaser's approval.
- d) Primary Injection Test for various currents & time settings shall be provided in routine test.
- e) All the components shall be tested for their entire operating range & certification for the same shall be provided at the time of inspection.

➤ Maintenance Requirements

- a) 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 Contractor shall supply one complete set of such tools along-with the equipment.

- b) Contractor shall furnish detailed inter panel wiring diagrams, internal wiring diagrams, detailed component layout drawings to carry out maintenance work.

➤ Drawings / Documents Required:

- a) Dimensioned general arrangement drawings of capacitor and capacitor control panel.
- b) Justification for number of steps for switching.
- c) Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation side view, sectional view and foundation details.
- d) Complete schematic and wiring diagrams for capacitor control panel.

1.4.8 DC SYSTEM :

Scope : DC system (as applicable) shall include the following:

- a) One set of 110 V DC, maintenance free rechargeable sealed lead acid batteries of adequate AH capacity shall be provided for control of switchgears in the Plant.
- b) Batteries shall be provided with battery charger cum DC distribution board. Battery charger shall include a float & float cum boost charger, indicating lamps and annunciations.

➤ Sealed Maintenance Free Lead Acid Battery:

- a) Applicable Standards: The sealed maintenance free lead acid battery shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification this specification shall govern.

Sealed lead acid: IS: 1651, 1652 BS: 6290

- b) The sealed batteries shall be a starved electrolyte type with electrolyte immobilized in a micro-porous material to allow recombining of generated oxygen internally. The battery shall be completely explosion resistant, shall tolerate freezing and shall not allow gases to escape during normal charging conditions. The battery shall not require any watering and be maintenance free.

- c) Positive Plates: Positive plates shall be either of cast solid in pure lead in one piece with plate formation and shall have adequate mechanical strength or of tubular plate which shall consist of a suitable bar with spines cast of suitably alloyed lead to give adequate mechanical strength or of pasted positive plates consisting of either pure lead, low anti-monial lead alloy or lead calcium positive grids; having double separation with a glass wool retainer mat or any other suitable material placed against the surface of the positive plates for good service life.
- d) Negative Plates: The negative plates shall normally be of the box type. End negative plates, if of box type may be of the half pasted type. Pasted plates shall have adequate mechanical strength and shall be so designed that the active material is maintained in intimate contact with the grid under normal working conditions.
- e) Containers: The containers shall be made of plastics, or fiber reinforced plastics (FRP). The container shall be spill proof, leak proof, explosion resistant and increased safety type enclosure.
- f) Vent Plug: The vent plug shall be for safety pressure vent and of self resealing type.
- g) Separators: The plate separator shall consist of a micro-porous matrix which shall serve as the mobiliser for the electrolyte. The battery separator shall maintain the electrical insulation between the plates and shall allow the electrolyte to permeate freely.
- h) Connectors and Terminal Posts: Inter-cell and inter-tier connectors and terminal posts shall be of Copper. Terminal posts shall be designed to accommodate external bolted connection conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the inter-cell connection. The top hole shall be left for terminal connections. All the metal parts of the terminals shall be lead coated. The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of electrolyte.
- i) Electrolyte: The electrolyte shall be battery grade sulphuric acid conforming to latest editions of relevant standards. The sealed battery shall be transported with the electrolyte immobilized, sealed and fully charged.
- j) Accessories: The battery shall be complete with accessories and devices, including but not limited to the following:

- i. Battery racks
- ii. Set of intercell, inter-tier and interbank connectors as required for the complete installation.
- iii. One Voltmeter with suitable range and leads for measuring cell voltage
- iv. Insulated wrencher.
- k) One set of terminals and cable boxes with glands for connecting cable as required.
- l) Battery Racks: Battery racks shall be constructed from good quality teak wood and painted with two coats of approve alkali resisting paint. The construction of the racks shall be suitable for fixing to a flat concrete floor. The racks shall be rigid, free standing type and free from warp and twist. The completed racks shall be suitable for being bolted end to end to form a continuous row. Insulators shall be provided below the legs of the stands.
- m) Capacity: The standard ampere-hour capacity at ten hour rate of discharge of the battery has been based on the requirements of loads as applicable and the minimum ambient temperature specified. Contractor shall guarantee that the capacity of the battery offered by him is adequate for the duty specified (all loads being coincident from the instant of supply failure even at the minimum ambient temperature as specified) assuming that the battery is fully charged to
 - i. 2.15 V at the start of the cycle
 - ii. 1.75 V/ cell at the end of the cycle.
- n) The Battery sizing basis shall be IEEE 485 & the Contractor to note that the Battery sizing shall be done considering design ambient Temperature of 50°C & Following factors.
 - i. Design Factor - Min. 1.1
 - ii. Aging Factor - Min. 1.25
 - iii. Temperature Correction Factor - Min. 1.1
- o) Cell Identification: Each cell shall be marked in a permanent manner to indicate the following information:

- i. Cell number
 - ii. Type of positive plate
 - iii. Ah capacity at 10 hour rate
 - iv. Type of container
 - v. Manufacturer's name
 - vi. Month and year of manufacture.
- p) Drawings/ Document: The complete battery layout drawing shall be furnished as part of the tender and also after award of contract for Purchaser's approval

➤ Battery Chargers:

- a) The battery charger and D.C. Distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Basic climatic and mechanical durability tests for IS:9000
components for electronic and electrical
equipment

Environmental tests for electronic and electrical IS:9000
equipment

Metal clad base material for printed circuits for IS:5921
use in electronic and telecommunication
equipment

Transformers and inductors (power, audio, pulse IS:6297
and switching) for electronic equipment

Printed wiring boards IS:7405

Environmental requirements for semi-conductor IS 6553
devices and integrated circuits

Terminals for electronic equipment IS:4007

Factory built assemblies of switchgear and control gear for voltages up to and including 1000 V AC and 1200 V DC	IS:8623/BS: 5486 / IEC:439
Air break switches	IS : 13947 (Part-3) BSEN 60947-3
Miniature circuit breakers	IS 8828/BSEN:60898
HRC cartridge fuses	IS:9224/BS:88
Contactors	IS:13947 (Part – 3) /BS:775/ IEC:158-1
Control switches/push buttons	IS:6875
Degree of Protection	IS:13947- (Part 1) /IEC:947-1
Climate-proofing of electrical equipment	BSCP:1014
Code of practice for phosphating iron and Steel	IS:6005/BS:3189
Semi-conductor converters	IEC:146
Semi-conductor rectifier equipment safety code	IS:6619
Specification for copper rods and bars for electrical purposes	IS : 613

b) Requirements: The Battery Charger shall be microprocessor based & shall have two chargers mainly – i) Float Charger ii) Float cum Boost Charger.

c) The float & float-cum-boost type battery charger shall comprise silicon controlled rectifiers (SCRs) connected in a full wave bridge circuit. Each battery charger shall be suitable for float charging the battery under normal conditions and boost charging the battery when it has discharged during service conditions. The changeover from float to boost mode and vice versa shall be automatic. Microprocessor shall be MU 1000C or Equivalent makes from the approved makes.

d) The rectifier transformer shall be dry type and double wound with required number of taps. The DC output voltage during float charging shall be stabilized within $\pm 1\%$ of the set DC bus voltage for AC input voltage variation of $\pm 10\%$, frequency variation

of $\pm 5\%$ and DC load variation from 0 - 100%. The voltage regulation shall be achieved by a constant voltage regulator having fast response SCR control. The ripple content shall be within $\pm 1\%$ of DC output nominal voltage with battery disconnected and shall be designed to have voltage regulation of $\pm 1\%$. Also in any mode of operation, the maximum harmonics in the charger output shall not exceed 5%. The setting of the output DC bus voltage shall be adjustable between $\pm 10\%$ of nominal rated voltage. There shall be provision for manual control if auto mode fails. Line surge suppressers shall be provided.

- e) If the spare float charger supplying DC load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes. Two blocking diodes in series shall be provided to take care of short circuit of any one diode
- f) For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. The boost charging shall come on only when selected for boost mode manually. In auto control, the DC output current shall be stabilized within $\pm 2\%$ for AC input voltage and frequency variation of $\pm 10\%$ and $\pm 5\%$ respectively. There shall be provision for manual control if auto-mode fails. The boost charge voltage and current settings shall be adjustable between 70 to 100% of maximum boost charge voltage and between 30 to 100% of maximum boost charging current.
- g) Boost charging time for charging the battery to full capacity from fully discharged condition shall not exceed 8 hours.
- h) In the float charging mode, the charger shall be designed for supplying:
 - i. The DC loads of control, indication and annunciation circuits that remain energized during normal operation and the momentary closing and trip coil loads of circuit breakers, vacuum contactors; and
 - ii. The float charging current of the battery.
 - iii. 25% margin over the above load.
- i) Battery charging equipment complete with all accessories shall be housed in a free standing sheet steel cubicle having degree of protection of IP 42. Sheet steel used

for construction shall be 2 mm thick. The units shall be wired using 1100 V grade, FRLS PVC insulated, multi-stranded Copper conductor cables.

- j) During boost charging the DC bus load shall be connected via two diodes in series connected to the tap cell of the battery. This is to take care in case of failure of standby charger supplying DC load.
- k) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily marked test pins.
- l) All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.
- m) All components and modules shall be clearly and unambiguously marked and all wiring colour coded and tagged
- n) Each battery charger shall be provided with accessories that include, but not limited to the following:
 - i. Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilization of $\pm 1\%$ and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance. The controller shall also be suitable for boost charging the battery in case of float-cum-boost charger.
 - ii. Boost charge current limiter with potentiometer to adjust the setting
 - iii. Silicon controlled rectifiers connected in full wave bridge circuit with ripple control devices and transient suppression network.
 - iv. 240 V AC compact fluorescent lamp fixture for internal lighting with MCB
 - v. Automatic voltage regulator unit with manual / auto control switch

- vi. Double wound, dry type, three phase suitably rated mains transformer with fuse protection and with one set of power factor correction capacitors to maintain a power factor of 0.85 (lag).
- vii. Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilization of $\pm 1\%$ and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance.
- viii. Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.
- ix. Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit
- x. Coarse and fine control potentiometers for manual control
- xi. Selector switch for mode of charging i.e. float charging / boost charging
- xii. Off-load tap changing switch for changing the taps of the transformer
- xiii. DC voltmeter with fuses and a three position selector switch
- xiv. DC ammeter with shunt
- xv. AC ammeter with selector switch for incoming AC power
- xvi. AC voltmeter with selector switch for incoming AC power
- xvii. MCB for incoming AC supply along with surge suppressers
- xviii. MCB on DC output side with kick fuses and alarm contacts
- xix. Voltage dropping diodes in load circuit during boost charging mode
- xx. DC under voltage relay and earth fault relay
- xxi. AC/ DC switching relays for alarm and indication circuits including buzzer

xxii. Cubicle space heater suitable for 230 V AC, 1 ph, 50 Hz supply, with MCB and thermostat

xxiii. Each battery charger shall be provided with the following alarms / indications:

- AC and DC supply 'ON'
- AC and DC supply fail
- Modes of charging
- Over voltage
- Under voltage on DC side
- Earth fault on DC side
- AC/ DC MCB trip

o) The DC circuit switching shall be through DC MCBs only.

p) Power Electronic Components

- i. Diode and thyristors shall be of mono-crystalline type silicon, capable of providing continuous output at specified voltages. It shall have high power efficiency.
- ii. If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly.
- iii. Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.
- iv. Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.
- v. The diodes or thyristors shall be protected against overvoltage due to chopping surges with the aid of snubbers (i.e., resistor-capacitor combination and Metal oxide variator

➤ DC Distribution Board:

- a) The distribution board shall be of floor mounting design. Entry for incoming and outgoing cables shall be from the bottom. Bus bars shall be of Copper. Incomers, bus coupler and outgoing circuits shall be controlled by suitably rated double pole MCBs suitable for DC application.
- b) Constructional features, pre-treatment, painting and other aspects shall comply with the specifications for LV switchboard.
- c) An earth busbar of 25x3 mm copper flat shall be provided along the length of the DB at the bottom. Two nos. earthing terminals shall be provided on the external face of the board for connection to the earthing grid.

➤ Tests:

- a) The batteries, chargers and distribution boards and their components shall be subjected to routine/ acceptance tests as per the applicable standards. For battery & battery charger, following tests are also to be carried out:
 - i. Visual checks for dimensions and general arrangement.
 - ii. Wiring checks.
 - iii. Functional checks.
 - iv. IR Test.
 - v. Capacity test.
 - vi. Test for voltage charging and discharging.
 - vii. Ampere-hour and watt-hour efficiency test.
 - viii. Hipot test, excluding electronic controller, at 2 kV AC for one minute.
- b) Certificates of type tests carried out on similar equipment not older than 5 years shall be furnished by Contractor.

➤ Drawings / Documents Required:

After award of contract Contractor has to submit the below mentioned drawings/ documents for Purchaser's approval :

- a) Dimensioned general arrangement drawings

- b) Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details
- c) Complete schematic and wiring diagrams.
- d) Detailed BOM for the complete panel, with details of switchgear, controller, components etc.

1.4.9 CABLING SYSTEM:

- The scope shall be inclusive of supply, installation, testing & commissioning of power & control cables, cable terminations, cable accessories, stripping of cable insulation, supplying and fixing of Aluminium lugs for aluminium cables & tinned plated copper lugs for copper cables and crimping the same to the conductor, supply and fixing of double compression cable glands including all labour supply and consumable material required for jointing/ termination. The rate shall also include the laying of cable in ground/ in cable trays / cleating to structure etc.

➤ Applicable Standards:

The cables shall confirm to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

PVC insulated cables	:	IS: 694
(for voltage up to 1100 V)		
HRPVC & PVC insulated cables	:	IS: 1554
heavy duty		
Cross linked polyethylene insulated	:	IS: 7098
PVC sheathed cables		
Low frequency cables and wires with	:	IEC: 189-1 &
PVC insulation and sheath		IEC-189-2
PVC insulation and sheath of electric	:	IS: 5831
cables		
Polyethylene insulation and sheath for	:	IS: 6474

electric cables

Conductors for insulated electric cables	:	IS: 8130
Methods of test for cables	:	IS: 10810
Specification for drums of electric cables	:	IS: 10418
Specification for PVC insulated cables	:	BS: 6346
for electricity supply		
Specification for PVC insulation and	:	BS: 6746
sheath of electric cables		

➤ Constructional Features:

- a) The HT power cables shall be three core, stranded, Aluminium conductor, screened by extruded semi-conducting compound, cross-linked poly ethylene (XLPE) insulated, cores screened with non-magnetic metallic tape laid up with inner and outer extruded PVC sheath compound Type-ST2 and galvanized steel strip armouring. The cables shall generally conform to IS 7098-1985 with relevant parts thereof.
- b) Armouring shall confirm to latest version of IS: 3975.
- c) The LV Power cables shall be 1.1kV grade, 4/ 3.5/ 3 Core, multi-stranded, Al/ Cu conductor, XLPE insulated, extruded inner & outer PVC sheath compound type ST2 and galvanized wire (up to 6 sq mm) / steel strip(>6 sq mm) armoured cables. All single phase, Lighting cables, UPS cables shall have 100% Neutral.
- d) All the control cables shall be 1.1kV grade, no. of cores (as per requirement/ application with minimum 2 spare cores for 7C & above) multi-stranded, Copper conductor, XLPE insulated, extruded inner PVC & outer PVC FRLS sheath compound type ST2 and galvanized steel round wire armoured.
- e) All control cables shall be with following specific requirements:
 - i. Copper conductor stranded class 2.
 - ii. XLPE Insulated

- iii. Provided with inner extruded PVC and outer PVC FRLS sheath of extruded black PVC compound.
- iv. Galvanized steel armouring in the form of GI round wire.
- v. Core identification shall be by printed numerals.
- vi. The insulation over the individual conductor core will be colour coded.
- vii. Minimum 2 spare cores for above 7C.
- f) The DC power supply cable shall be two core, multistranded copper conductor, armoured cables with inner extruded PVC & outer PVC FRLS sheath. All control wiring shall be PVC FRLS insulated.
- g) All the power & control cables used in the Hazardous area shall be flame proof type suitable for the intended application.
- h) Earthing Cable shall be Single core multi-stranded Cu, 1.1 kV grade, XLPE insulated, un-armoured green coloured outer sheath with yellow strips/ band cable to be laid in trays, underground, trenches etc. as applicable.
- i) 1.1 kV XLPE Insulated Submersible cables: Multi core flexible Cu conductor XLPE insulated & PVC sheathed heavy duty cable suitable for submersible application (in case of submerged pumps) shall be manufactured as per governing standards. High purity electrolytic grade, annealed Cu conductor shall be used. Cables shall be extruded inner & outer PVC sheathed. PVC compound shall be dielectric grade & shall be impervious to water, oils & grease etc. Similarly double PVC sheathing shall also be done as per IS: 5831/ 1984. Flexible inner sheath & high abrasion resistant flexible outer sheath is required for these cables. Double PVC sheathing shall be done so as to withstand abrasion & prevent ingress of water along the interstices of the cable. Core identification shall be by printed numerals. Conductors shall be as per IS 8130. Cable shall be constructed as per relevant IS/ IEC standards.

➤ Cable Colours:

- a) All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

b) The colour coding should be as follows:

- | | |
|-------------------------------|---------------------------------------|
| i. 3 phase | Red, Yellow and Blue |
| ii. single phase or dc supply | Red and Black |
| iii. earth | Green/Green with Yellow coloured band |
| iv. control | Gray (DC) |

➤ Cable Conductors:

a) Cables up to 4 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured & balance cables shall be Al multistranded conductor with galvanized steel round wire/ flat strip armoured.

b) Single core cable shall have non magnetic material armouring.

c) Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm².

d) Small control cables shall be of a minimum cross-section of 1.5 mm².

e) Internal wiring of control panels shall be of a minimum cross-section of 1.5 mm² flexible and multistranded.

f) Instrumentation and control cabling shall be of a minimum cross-section 1.5 mm² for external use and 1.0 mm² for internal use.

g) Cable Sizing shall be done as per design criteria specified in specifications.

➤ Cable Numbering: All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Necessary loop at both ends shall be provided for future use and cables of different categories shall be tagged with the following subscripts and three digit number.

HV power	HV-P_ _ _
LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _

Telecommunication T _ _ _

➤ Cable Terminations:

a) Cable Lugs

- i. Cable lugs shall be of tinned copper, solder less crimping type for Cu cables & AL lugs for the AL cables.
- ii. The current rating of the lugs shall be same as that of the respective cable conductors.
- iii. Bi-metal strip/ Bi-metallic lug shall be used whenever two different metals are to be connected together.
- iv. Double holes extended neck (long barrel neck) type lugs shall be used in case of cables above 185 sq. mm.
- v. Anticorrosion/ anti-oxidation compounds shall be used for crimping lugs. This shall especially be ensured for Al cable terminations & bimetallic terminations shall be used wherever required.
- vi. If termination is done with crimping tool employing crimping die then forming dies shall be used to make the sector shaped conductor into a round conductor before crimping the lugs on the conductor. The lug must not be crimped directly on the sector conductor. Before crimping the lug, the conductor shall be thoroughly cleaned and special jelly applied over it to prevent further oxidation.

b) Cable Glands

- i. Glands shall generally be of the double compression hexagonal type brass glands. Earth continuity of brass glands shall be assured.
- ii. Double compression type cable glands shall be used. Cable glands shall be brass casting, machine finished and Nickel-plated to avoid corrosion and oxidation. Rubber components used in cable gland shall be of neoprene.
- iii. For single core cables, gland shall be with brass ring.
- iv. Glands for single core cables shall be constructed from non-magnetic materials.
- v. Cable glands shall be with metric threads.

- vi. Where holes for cable entries are not provided it shall be the responsibility of the Contractor to mark out and drill such holes. Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.
- vii. For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used and entry shall be sealed.
- viii. For dry indoor situations, standard industrial glands with shrouds are acceptable.
- ix. For hazardous areas, glands conforming to EEE standard shall be used with double seal and shroud.

c) Trefoil Clamps for Single Core Cables.:

- i. All the single core cables shall be laid in trefoil formation only.
- ii. The grouping & sequencing of three single core cables arranged in trefoil formation shall be done in such a way to ensure balanced current distribution.
- iii. Trefoil clamp of suitable size & having non magnetic material shall be used.
- iv. The Trefoil groups shall be held in trefoil clamps at an interval not exceeding 3.0 meters.
- v. In addition to trefoil clamps as mentioned above, the tre-foil groups of cables shall be additionally tied by means of 3.0 mm dia. nylon cord clamp at an interval not exceeding 750 mm.

- d) Where ever applicable, supply & installation provision of bimetallic strip for connection between Al to Cu strip & GI to Cu strip shall be provided.

➤ Cable Drums:

- a) Cables shall be supplied in non-returnable wooden drums. 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.

- b) Before winding the cables on drums, Contractor shall obtain Purchaser's approval for the drum lengths. Cable ends shall be sealed by non-hygroscopic sealing caps.
 - c) Contractor has to ensure reference of an arrow and suitable accompanying wording which shall be stenciled on the sides of the drums indicating which way it should be rolled. The number on each drum shall be either branded at the end of the drum or stamped on the metal attached to an end of the drum. The cable shall be placed on the drum in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. The drum shall be securely blocked in position so that the cable will not be displaced during transit. Cable ends shall be sealed by non-hygroscopic sealing caps.
 - d) It shall be the Contractor's responsibility to prepare the drum cutting schedule so that cable wastage is minimum while cutting.
 - e) Contractor shall obtain Purchaser's approval for the drum lengths.
- Tests Before and After Laying of Cables at Site: Following Routine & acceptance tests on each drums as per IS 10810, IS 7098 standard & other specified relevant standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's Representative.
- a) For 1.1 kV Power & Control cables:
 - i. Dimensional & visual check
 - ii. Conductor resistance test
 - iii. Insulation Resistance Test
 - iv. High voltage test
 - b) For 11 kV power cables:
 - i. Design and visual check
 - ii. Conductor resistance test
 - iii. Very low frequency AC HV test (instead of DC test)
 - iv. Insulation resistance including P.I. at rated voltage
 - v. Capacitance and tan delta

vi. AC leakage current

vii. Partial discharge measurement

c) All HV cables shall be subjected to DC or AC (preferably DC) high voltage test after terminating but before commissioning as per Table 6.0 in IS: 1255 (Code of practice for Installation & Maintenance of Power Cables up to and including 33kV).

d) Cables shall be checked for insulation resistance before and after jointing. The voltage rating of the Megger for cables of different voltage grades shall be as indicated below.

a) Voltage Grade	a) Megger rating
b) 1.1kV	b) 500V
c) 22 kV and 11kV	c) 1000V

e) Following tests in the presence of Purchaser/ Purchaser's representative shall be carried out at site before commissioning of cables.

i. Insulation Resistance test between phases and phase to Neutral and phase to earth.

ii. Continuity test of all the phases, neutral and earth continuity conductor.

iii. Sheathing continuity test.

iv. Earth resistance test of all the phases and neutral.

➤ Drawings / Documents Required:

a) As a part of the Bid, Contractor shall furnish the following :

i. General information

ii. Principal technical data

b) After award of contract it shall be the responsibility of Contractor to work out a detailed layout for the complete plant cabling system. The layout drawing shall be furnished for the approval of Purchase/ Purchaser's representative before commencement of installation including cable trays, cable racks/ trenches, accessories, tray supports, conduits etc.

- c) Contractor to submit following Drawings /Details after award of contract
 - i. Cable Sizing calculations
 - ii. Details of Installation of Cables in Trenches, on Cable Trays, Directly buried etc at all locations inside the plant.
 - iii. Cable routing lay out inside and outside the plant with route marker provided at 30 meter interval.
 - iv. Bill of quantities of cables, lugs and glands.
 - v. HT Cable termination and mounting Kit Layout drawing.
- d) Following Type Tests reports as per relevant standard to be submitted for the same rating & type of Cables conducted in past for review of Purchaser/ Purchaser's Representative by the Contractor at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.
 - i. Annealing test
 - ii. Tensile test
 - iii. Wrapping test
 - iv. Test for thickness of insulation & sheath
 - v. Physical test for insulation & sheath
 - vi. Tensile strength and elongation at break of insulation and sheath
 - vii. Loss of mass test
 - viii. Ageing in air oven
 - ix. Shrinkage test
 - x. Heat shock test
 - xi. Insulation resistance test
 - xii. High voltage test
 - xiii. Flammability test

1.4.10 EARTHING & LIGHTNING PROTECTION SYSTEM:

➤ Scope:

a) The scope includes collection of data, design of the system as per relevant National/International Standards preparation of layout drawing supply of earthing conductors, earth electrode, earthing strips installation and approval to the satisfaction of electrical inspector under this tender specification.

b) Earthing system shall be provided to ensure equipment safety, personnel safety and facilitate designed operation of protective switching during earth fault conditions in the associated system.

➤ Applicable Standards: The earthing and lightning protection system shall conform to the CEA guidelines and the latest applicable standards indicated below:

a) Code of Practice for Earthing : IS: 3043

b) Code of Practice for the Protection of : IS/IEC 62305

building and allied structure against Lightning.

c) Hot dip galvanizing : IS: 2629, 2633, 4759

d) Structural steel : IS: 2062 & 808

e) Welding : IS: 816

➤ Earthing & Lightning system:

a) The design basis for designing earthing conductor is indicated under design criteria for electrical system. Earthing system shall be provided for complete plant i.e. pumping stations, switchyard and all electrical equipments as per the latest edition including all official amendments and revisions of IS-3043 and CEA guidelines.

b) All materials and fittings used in the earthing installation shall conform to the relevant Indian Standards or shall be approved by the Engineer's representative & CEIG.

c) Contractor has to carry out soil resistivity test at, at least 4 locations for which locations shall be provided by Purchaser's representative. Testing to be done at each site.

- d) Soil resistivity shall be carried out by Wenner four electrode method as described in IS 3043. Contractor has to carry out the test in presence of Purchaser's representative & test shall be carried out keeping electrode spacing as 1, 2, 4, 6, 8, 10, 15, 25 M (each, along all 8 directions) as per normal practice and report has to be submitted. Polar curves shall be used for measurement of mean soil resistivity, which shall be used in finding earthing resistance at a particular location. Mean soil resistivity values shall be approved by Purchaser's representative.
- e) The contractor shall base his earthing calculations on actual measurement carried out by him in the presence of Purchaser/ Purchaser's Representative.
- f) Galvanized Iron flat / wire shall be used as earthing conductor.
- g) The conductor sizes & types shall be as per specified in the Technical schedules in Volume – II, Section A3. Contractor to note that, the sizes indicated are minimum required & earthing conductor sizes shall be approved by the Purchaser/ Purchaser's representative on the basis of adequacy calculations submitted by Contractor.
- h) The underground joints in the system shall be properly welded or brazed and the bolted type connection shall be made with structures/ equipments. Petroleum jelly shall be applied to contact surface of the bolted joints, which will be covered with bituminous compounded and tapes.
- i) Earthing conductor shall be protected against mechanical damages considering the installation conditions.
- j) The earthing system shall comprise one or more earth electrodes, earthing grid or a combination of these in order to obtain the required earth electrode resistance of less than 1 Ohms.
- k) For equipment earthing, two earthing leads will be used if rated voltage of the equipment is 250 volts & above and one earthing lead will be provided for equipment rated below 250 volts.
- l) The earthing conductors in outdoor areas shall be installed at a minimum depth of 600 mm below FGL.
- m) For each DP Structure, minimum 2 nos. of GI plate type earthing electrodes shall be provided. The earth plate shall be buried in specifically prepared earth pit- 3 mtr.

below ground with alternate layers of charcoal and salt, 40 NB GI pipe with funnel with a wire mesh for watering and bricks masonry block and CI Cover complete as per IS 3043 with necessary length of double GI earth flat 25x6 mm bolted with lug to the plate complete connected to the required point of DP with end socket as per direction and duly tested by earth tester conforming to IS as per drawing and specifications complete with 60 x 60 x 0.35 cm CI earth plate.

- n) For each transformer neutral, minimum 2 nos. of Cu plate type earthing electrodes shall be provided. The earth plate shall be buried in specifically prepared earth pit 3 mtr. below ground with alternate layers of charcoal and salt, 40 NB GI pipe with funnel with a wire mesh for watering and bricks masonry block CI Cover complete as per IS 3043 with necessary length of double Copper earth flat 25x6 mm bolted with lug to the plate complete connected to the transformer neutral with end socket as per direction and duly tested by earth tester conforming to IS as per drawing and specifications complete with 600 x 600 x 3.15 mm Copper earth plate.
- o) For other equipment & area, 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 the driven length.
- p) Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing strips shall be connected. These connections shall each be housed in individual inspection chamber set which shall project 100 mm above the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked 'Electrical Earth'.
- q) All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the Purchaser's Representative.
- r) All civil works, such as excavation, boring, provision of charcoal & salt in adequate quantity, backfilling for the installation of the earth electrodes and the earth pit/ inspection pit shall be in the scope of Contractor.
- s) After the earth installation has been completed the Contractor shall demonstrate to the Purchaser/ Purchaser's Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any

additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

- t) Main Equipotential Bonding Conductor: Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.
- u) Circuit Protective Conductors: An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:
 - i. a separate core within a multicore cable
 - ii. A separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor
 - iii. The metal sheath of an armoured cable. The sheath shall be bonded to the metal work of the apparatus and to the apparatus earth bar if any
 - iv. the copper sheath of a mineral insulated copper sheathed cable
 - v. An independent earthing conductor MS or GS run adjacent to the circuit it protects.
 - vi. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.
 - vii. The armoring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.
- v) Instrumentation Earth:
 - i. An instrumentation earth bus shall be provided in each control panel. This shall comprise a GI flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the control panel electrical power earth.
 - ii. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection

to the same point as before on the control panel electrical earth bar. In this fashion all instrument earths shall be connected radially from the same earth point.

- iii. All signal cable screens (analogue and digital) shall be terminated on to the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.
- iv. Surge Protector Devices (SPDs) associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

➤ Important Instructions for Earthing:

- a) Each pole of lightning arrestors shall be earthed with separate earth pit.
- b) Two-earth conductor shall connect outdoor CT secondary winding to earth grid.
- c) The switchyard fencing shall be earthed at every alternate block and the switchyard gate shall be earthed with flexible GI wire.
- d) All the earthing material with laying etc. shall be included in the scope.
- e) The entire plant will have an earth grid laid in trenches/ trays/ buried in the ground outside. The main earthing grid shall be embedded at a minimum depth of 600 mm below FGL which shall be connected to earth electrodes.
- f) All interconnections of the earthing grid conductors will have welded type joints except at electrodes with disconnecting facility and at equipment with bolted connections. All indoor earthing grids will be suitably interconnected to the external earthing grid.
- g) Each steel/ RCC column of the building will be interconnected to the floor-earthing grid. Steel columns, steel strips / conduits, cable trays etc. will not be used as earth continuity conductors.
- h) Disconnecting type facility shall be provided between Earthing grid & each earth electrode.
- i) All connection between the conductors shall be welded/ brazed type. Metallic pipe, conduit, structures shall be bonded to lightning protection conductors to prevent the

side flashover. But no metallic pipe, conduit, structure shall be used as air termination conductor or down conductor.

- j) The down conductors shall be fixed with embedded brass posts (on concrete columns) with nuts & bolts used for fixing the saddle/ clamp (direct drilling of down comer and fixing with screw shall not be acceptable).
- k) Cleats for 'earthing and lightning protection systems' shall be of GI.
- l) The lightning protective conductor shall not be connected with the earthing above ground however both the systems shall be interconnected below ground.
- m) The earth pits may require boring & drilling in the soil & the same shall be considered in contractor's scope.
- n) Earth electrode with disconnecting facility shall be provided so that the resistance of the independent earth electrode may be measured.
- o) Internal earth Bus of each panel shall be connected to both ends to the earthing system by means of earthing conductor.
- p) Metallic frames of all current carrying equipment, structures supporting and adjacent to current carrying conductors, lightning protection system conductors, metallic structures, metallic stairs, hand rails, fences shall be connected to a single earthing system. Neutral points of various systems shall be connected to the dedicated treated earth pits and these earth pits shall be interconnected to each other below ground.
- q) All connections in the equipment earth conductors buried in ground (or otherwise) shall be cad welded / brazed, whereas connection at equipment end shall be of bolted type. All connections shall be of low resistance. All bimetallic connection shall be treated with suitable compound to prevent moisture ingress. For Bimetallic bolted connection, bimetallic washers shall be used. All bolted joints shall have minimum two bolts to ensure proper surface contact. Termination of stranded conductors at earth inserts shall be with ring type/ lugs.
- r) Galvanized conductors shall be touched up with zinc-rich paint where holes are drilled at site for bolting to equipment/structure.

- s) Suitable earth risers approved by the Engineer shall be provided above finished floor/ ground level, if the equipment is not available at the time of laying of the main earth conductor. The minimum length of such risers inside the building shall be 200 mm and outdoor shall be 500 mm above ground level.
- t) Metallic conduits and pipes shall be connected to the earthing system unless specified otherwise.
- u) All cable trays will be earthed at minimum two places by suitable sized GI flats to main earthing system earth conductor. The cable trays shall also be earthed at a regular interval of not more than 10 meters by 25 x 3 mm GS flat
- v) Earthing Pits
 - i. Adequate number of earthing pits shall be provided in conjunction with earthing grid for the earthing system. The minimum spacing between two adjacent earthing pits shall not be less than length of the electrode (minimum 3 m) and shall be kept 1500 mm away from footings of the structure.
 - ii. Earthing pits shall be located in ground, which has a reasonable chance of remaining moist. Arrangement comprising of GI pipe with top funnel with wire mesh shall be made to facilitate pouring of water to keep earthing pit wet.
 - iii. A galvanized iron strip of adequate size (as per calculations) shall be provided from plate electrode to about ground level to facilitate jointing with earth conductors. Each earth electrode ending at the pit shall be connected to suitable linking strips to connect and disconnect the earthing suitably.
 - iv. Earthing chamber shall be of RCC / brick chamber of 600 mm x 600 mm, with removable 6 mm thick MS chequered plates. The covers shall have holes for handling. Earthing pits (chambers) shall be painted Green and the earth-pit number shall be marked on it.
 - v. Earthing cables crossing other metallic structures such as conduits pipelines etc shall be minimum 300 mm away from such structures.
 - vi. Earthing conductors shall be protected against mechanical damage.
 - vii. All earth lead connections shall be as short and direct as possible and shall be without kink.

viii. The main earth loop in plant area shall be generally routed along cables. When equipments are located away from main earth loops, suitable sub-loops shall be run up to them for deriving connections for individual equipment. The entire earthing system shall fully comply with the CEA guidelines and requirements.

ix. The contractor shall have to carry out any changes as desired by the Electrical inspector or the Engineer in charge, in order to make installation conforming to the CEA guidelines 2010.

➤ Lightning Protection:

a) The lightning protection system need will be established by calculating the risk factor value of each building, structure etc. as per procedure given in IS 2309-1989 and if found necessary the same shall be provided by the Contractor.

b) For Lightning protection of Civil Structures including RCC Buildings, fixing of 25x6 mm GI earth strip to roof as per IS/ IEC std, saddle clamp, down comer connector etc. as required with all hardware shall be in Contractor's scope. Structural Columns (which are used as down comers for lightning protection system) bottom shall be connected to the earth pit with 25x6 mm bare GI strip.

➤ Galvanizing:

a) Wherever galvanizing has been specified, the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below

<u>Fabricated Steel</u>	
i. Thickness less than 2 mm, but not less than 1.2 mm	340 gms/ sq.m
ii. Thickness less than 5 mm, but not less than 2 mm	460 gms/ sq.m
iii. Thickness 5 mm and over	610 gm/ sq.m
<u>Fasteners</u>	
iv. Up to nominal size M10	270 gms/ sq.m

v. Over M10	300 gms/ sq.m
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- b) Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminium paint.
- c) Contractor shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.

➤ Drawings/ Documents Required:

The Contractor should prepare Layout drawings, after award of contract and before commencement of work for Purchaser's approval, showing the location of earthing grid, electrodes, interconnection grids and earthing leads to various equipment, down comers, isolating links etc. should be accompanied by design calculations.

2.2. LIGHTING & RECEPTACLE SYSTEM:

➤ Scope

- a) The scope of the Contractor shall include design, supply and installation of all equipment necessary for a complete lighting and receptacle system. The lighting system includes Lighting fixtures (indoor/ outdoor), lamps, lighting panels (LP), switchboards, Receptacles, JBs, cables/ wires for lighting/ receptacles, conduits etc. The supply of street light / flood light poles as per IS 2713 or IS 3713 is also included in the Contractor's scope.
- b) The various types of lighting fixtures as per specified in this specifications shall be assembled, installed, tested & commissioned by the contractor.
- c) The type of lighting fixtures and receptacles, illumination level and approximate quantity required shall be generally as per design criteria.
- d) All luminaries shall be LED.
- e) Lighting system installation shall be as per the tender specifications
- f) It shall be the responsibility of the Contractor to work out complete detailed requirement of lighting and receptacle system for the whole plant and staff quarters including area lighting as per specification and accordingly procure and install them.

➤ General Requirements: The Lighting system includes following items.

- a) Lighting fixtures complete with Lamps and accessories
- b) Lighting system equipment
- c) Light control switches, receptacle units with control switch units, lighting wires, conduits, earth wires and other similar items necessary to complete lighting system.
- d) Lighting fixture supports, street lighting poles and flood light towers/ poles.
- e) Lighting main distribution board, lighting panels
- f) Multi core cables for street, boundary and flood lighting

➤ Lighting Layout:

- a) It shall be the responsibility of the Contractor to work out a detailed layout for the complete plant in order to provide the levels of illumination as indicated in the relevant standards
- b) The types of fixtures to be used in various areas are also indicated in the above mentioned drawing. The Contractor shall be responsible for measuring the levels of illumination and uniformity after installation and establish compliance with the specification.
- c) The lighting system will comprise the following:
 - i. Normal A.C Lighting : Normal lighting in all indoor and outdoor areas will be operated on 230V, 1Phase, 50 HZ A.C supply
 - ii. Emergency Lighting: Emergency Lighting shall be designed such that at all junctions, exit passages & strategic locations, Lux level shall be maintained above 10 Lux. Emergency light fitting shall be 240 V self contained 2 x 10 W fluorescent tube with built in Ni-Cd battery having charging facility and six hours back-up time. The emergency light fittings shall be provided at strategic locations of each house/ area. Emergency fixtures shall come in service when AC supply fails. Pump room and Electrical room shall be considered for Emergency lighting.

➤ Other Design considerations for Lighting:

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- a) Lighting panels shall be provided in various areas and circuit wiring to the lighting fixtures shall be made from lighting panels. Lighting panel shall comprise of Four pole MCB + RCCB (100 mA) for incomer and SP MCB's for each outgoing single phase circuits.
 - b) The wiring for lighting circuits in indoor areas will be done by wires run in GI conduits. For outdoor lighting, wiring will be done by using armoured cables.
 - c) Lighting cable from Main lighting DB (MLDB) to Lighting panels shall be Al conductor, XLPE insulated, 1.1KV grade, laid in cable trays otherwise cleated along the wall/ column/ beam.
 - d) For lighting fixtures (Pump room) 1100V grade, 4C x 2.5 sq. mm. PVC insulated, multistranded copper conductor armoured cables shall be used.
 - e) For lighting fixtures (For Office, electrical room, toilets etc. areas) 1100V grade, FRLS PVC, multi-stranded Copper conductor wires of area not less than 1.5 sq mm laid in min. 20 mm dia GI conduit (above false ceiling) shall be used.
 - f) For 5/15A decorative sockets (For Office, toilets etc. areas) 1100V grade, FRLS PVC, multi-stranded copper conductor wires of area not less than 2.5/ 4.0 sq. mm. Cu laid in minimum 20 mm dia. GI conduit shall be used.
 - g) Wiring shall be concealed in wall below false ceiling with concealed switch board. Minor civil work like chasing wall, cut outs for conduit, switch board, Lighting Panel in wall, entries for tray, conduits etc. is in scope.
 - h) Lighting cable from MLDB to Lighting Panels and Lighting Panels to street light fixtures, shall be Al conductor, XLPE insulated, armoured, 1.1 KV grade, laid in cable trays otherwise cleated along the wall/ column/ beam and buried in the ground.
 - i) The point wiring for lighting/ receptacle/ exhaust fan/ wall mounted fan / ceiling fan shall include conduits, conduit accessories, FRLS PVC insulated multistranded Copper conductor wires and earthing wires, pull boxes, ceiling rose, clamps, cleats, hardware, accessories, anchor fasteners etc. It shall include wiring from lighting panel to switchboard and receptacles & switchboard to lighting fixtures. Sheet metal switchboard embedded in wall shall be considered for receptacles and lighting switchboards on wall shall be considered for lighting.

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- j) For power sockets in wall / furniture, PVC switch box of approved make with switch plate & accessories and 16 Amp piano modular switches and 5/15A sockets etc. as applicable shall be considered. For all types of point wiring the receptacles with switches shall be included in the point wiring rate.
 - k) Lighting switchboard consisting of (*) no. of 6A piano switch without indicator, 1 no. 6A piano switch with indicator, 1 no. white coloured cover plate for (*) module(4/ 6/ 8/ 12 module), 1no. 2/ 3 pin shuttered socket of 5/15A and metal flush box.
 - l) Decorative socket switchboard consisting of (*) no. of 16A piano switch with indicator, (*) no. 2/3 pin shuttered socket of 5/15A and metal flush box, 1 no. white coloured cover plate for (*) module(4/ 6/ 8/ 12 module).
 - m) Lighting fixtures and fans will be grouped on the circuit wherever required. However, separate circuits shall be used for receptacles wiring.
 - n) Lighting Control Philosophy as per mentioned below shall be observed. From each switch –
 - i. Max. 2 (3 in case unavoidable) fluorescent luminaries (2x36W)
 - ii. Max. 4 (5 in case unavoidable) down lighters luminaries (2x18W)
 - o) All Street Light fixtures shall be controlled directly from respective Lighting Panels, through MCB.
 - p) Each lighting panel/ Receptacle DB shall have minimum 2 spare circuits of 10/16A SPN outgoing feeders. A circuit consists of R, Y, and B Phase each.
 - q) Lighting for staircase shall be controlled with flushed modular switch. The conduit for main staircase shall be concealed. Lighting for all staircases shall be with 2 way switch
 - r) Contractor shall note that any chasing in walls or cutouts or openings such as fixing of LPs, DBs, switchboards, concealing conduit in wall etc. in walls required shall be made before plastering of brickwork wherever applicable and installation rates quoted shall be inclusive of chasing, cutting & making the plaster as per standard practice.
 - s) Lighting for LED street light fixtures/ LED flood light fixtures shall be carried out with cables. The supply of cables, junction boxes, street light poles & structural steel
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required for mounting fixtures/ LPs etc. are in the scope of Contractor. The cable wiring shall include supply & installation of cable required from LP to the junction box mounted on street lighting pole / near indoor fixture and also between junction box mounted inside pole/near indoor fixture to control gear box and same for flood lighting, supply and installation of all termination accessories such as lugs, cable glands etc. DBO Contractor's scope shall also include excavation, preparation of soil bedding, supply and installation of protection cover, back-filling, supply and installation of cable route markers etc.

- t) Point Wiring for lighting/ raw power receptacle/ emergency lighting:
- i. Point wiring covers the wiring between a circuit of the lighting panel to switchboard and then from switchboard to lighting fixtures connected to that circuit of the lighting panel.
 - ii. For receptacle circuits point wiring shall cover wiring between circuit of the lighting panel to receptacles connected to that circuit of the lighting panel.
 - iii. The scope of the Contractor shall include the supply, erection, testing and commissioning of the above LPs/ DB boards for supply of power to the various sockets required for computers, raw power points etc. The point wiring rate from these DBs shall include supply of wires, conduits, cleats/ clamps etc. as may be required and shall be in the scope of electrical Contractor.
 - iv. The conduit point wiring rate for exhaust fan shall include conduits/ casing capping, conduit/ casing capping accessories, Switch boards, PVC insulated wires and earthing wires, pull boxes, ceiling rose, clamps, cleats, hardware, sheet metal switchboards fabricated out of 16 SWG. sheet steel housing 5 Amp piano switches. It shall include wiring from EXHAUST FAN DB/ RDB to switchboard & switchboard to exhaust fan as applicable. Neutral for individual circuit shall be run separate from DB to individual receptacles.
 - v. All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the CONTRACTOR under the scope of this contract.
 - vi. Required no. of 1-Ph & 3-Ph, industrial receptacles with respective 2P/ 4P ELCB (30mA) & 3/ 5 pin plug shall be provided for maintenance purpose.

vii. Receptacle & it's ELCB shall be mounted in prefabricated CRCA box of 16 SWG, epoxy painted with shade 631 of IS-5/ RAL 7032. Earthing studs shall be provided for connecting external earthing with receptacle box.

viii. The Configuration of Industrial receptacle units shall be as per following – Combination

- 240V, 1-Ph, 50Hz, 3 pin, 15A Industrial receptacles with RCBO (30 mA).
- 415V, 3-Ph, 50Hz, 32/63A Industrial receptacles with respective RCBO (30 mA).

u) Lighting Fixtures and Accessories:

i. General

Normal supply voltage, phase and frequency		240 V, 1 ph, 2 wire, 50 Hz,
Variation in supply		
Voltage (AC & DC)		± 10
Frequency		± 5
Combined voltage & frequency		± 10
Design ambient air temperature		50°C

ii. The Luminaries shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.

iii. Connections between different components shall be made in such a way that they will not work loose by small vibration.

iv. For each type of Luminaries the Contractor shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.

v. All Luminaries shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage, frequency and combined voltage and frequency of $\pm 10\%$, $\pm 5\%$ and $\pm 10\%$ respectively.

vi. The Luminaries and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.

vii. All Luminaries shall be LED type.

viii. Each luminaries shall have a terminal block suitable for loop-in, loop-out and T-off connection by 230/ 415 V, 1 core, FRLS PVC insulated Copper conductor wires up to 4 sq. mm in size. In outdoor areas the termination at the luminaries shall be suitable for 1100 V, PVC insulated, Cu/ Al conductor, armoured cables of sizes up to 6/ 16 sq. mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed 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.

ix. Mounting facility and conduit knock-outs for the luminaries shall be provided.

v) Earthing

i. Each luminary shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.

ii. Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.

iii. All metal or metal enclosed parts of the luminaries/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

w) Painting/ Finish:

i. All surfaces of the Luminaries/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.

ii. When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.

- iii. The luminaire housing shall be stove-enamelled/epoxy stove-enamelled-vitreous enamelled or anodised as indicated under various types of fittings.
- iv. The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. over 1/2" dia. mandrel.
- v. The finish of the luminaries shall be such that no bright spots are produced either by direct light source or by reflection.
- vi. External control gear box provided for housing accessories shall be painted or galvanised.
- Technical Requirements (LED lamps & fixtures):
 - a) Suitable number of LED lamps shall be used. In the luminaries LED lamps of NICHIA/CREE/ OSRAM/PHILIPS LUMILEDS\ Bridgelux make only shall be used. The manufacturer shall submit the proof of procurement of LEDs from above OEMs at the time of testing.
 - b) Suitable reflector / lenses may also be provided to increase the illumination uniformity and distribution.
 - c) Supplier will be solely responsible for testing and performance of the luminaries after installation.
 - d) Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.
 - e) The working life of the lamp at junction temperature of 85 Deg C at rated current shall be more than 50,000 working hours of accumulative operation and shall be suitable for continuous operation of 24 hours per day. These features shall be supported with datasheet.
 - f) Minimum view angle of the LED shall not be less than 120°.
 - g) 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 min 100lumens/watt or more and LED fixture shall have system efficacy of min 70 Lumens/watt or more.

- h) Bidder has to submit LM-79 (Electrical & Solid State measurement of solid state lighting products/fixtures). The test report shall contain Total lumen output of the fixture/Luminaries Intensity Distribution/Electrical Power/Luminous Efficacy/Color Characteristic of the fixture i.e. CCT & CRI
- i) Thermal management shall be in such a way that LED soldering point temperature shall not go beyond 75 degree centigrade.
- j) The LED luminaire shall be free of glare.
- k) Color rendering index CRI ≥ 75
- l) System luminous efficacy for indoor area shall be ≥ 80 .
- m) All luminaries shall be provided with toughened glass of sufficient strength and high efficiency (90%) prismatic diffuser under the LED chamber to protect the LED and luminaries. And shall not show yellowness during luminaries life time.
- n) If Housing is not used than heat sink shall be made of at least 0.8 mm thick sheet Steel conforming to IS: 513 (Grade O)/CRCA polyester powder coated of at least 80 microns) and high U.V. & corrosion resistance. Heat sink used should be aluminum extrusion having high conductivity preferably to grade 6061 alloy or better having thermal conductivity of at least 170-180 W/m.K or Aluminium die cast having high conductivity preferably ADC 12 or LM 24. Efforts shall be made to keep the overall outer dimensions as minimum as possible.
- o) Each luminaire shall be provided with an earthing terminal suitable for connection to the PURCHASER's earthing conductor of 12 SWG GI wire unless otherwise specified.
- p) Outdoor type lighting fixtures shall be designed using high pressure die cast Aluminium housing of IP 66 rating for protection against dust and moisture and IK 08 for protection against breakage.
- q) Each luminaire shall have a terminal block suitable for loop in, loop out & T-off connection by 1100V, 1 core, PVC insulated CU conductor wires up to 4 sq. mm in size. Terminal shall be stud or clamp type.

- r) Mounting facilities & conduit knock-outs for the luminaries shall be provided.
- s) Power factor of complete fitting shall be more than 0.95 at full load 240V & THD<8%.

- LED Driver Specific Requirement

- a. The driver should comply to CISPR 15 for limits and methods of measurement of Radio Disturbance characteristics.
- b. The equipment should comply to IEC 61547 for EMC immunity requirements.
- c. The control gear should be compliant to IEC 61347-2-13, IEC 62031 and IEC 62384 as per the requirements
- d. The equipment should be compliant to IEC 60598-1, IEC 62031 and IEC/PAS 62612 depending on the type of luminaries.
- e. Current waveform should meet EN 61000-3-2
- f. Output voltage ripple should be within 3%.
- g. Inbuilt surge protection of not less than 4KV to prevent in damage to the drivers in case of sudden voltage surge.

- Drawings/ Documents Required:

- a) As part of proposal, the Contractor shall furnish relevant descriptive and illustrative literature & drawings/ data for the respective lighting fixtures & accessories with manufacturer's catalogue numbers.
- b) It shall be the responsibility of the Contractor that, on award of contract to work out a detailed lighting layout for the complete plant in order to provide the levels of illumination as indicated under Design Criteria and shall be furnished for the approval of the Purchaser's representative before commencement of installation.
- c) Detailed Room wise Lighting Layout with Type of fixture details, mounting detail arrangement and Circuit diagram showing phase wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles etc.

- d) Conduit layout showing room wise routing of wires from lighting panel to lighting fixtures covering primary & secondary point wiring, receptacles etc.
- e) Internal road Lighting and Area lighting layout with type of mounting details and fixture details.
- f) Street Light pole details with Foundation details
- g) General arrangement of lighting panel & lighting distribution board showing plan, elevation and typical section views.
- Lighting System Equipment:
 - a) Main Distribution Boards and Lighting Panels
 - i. Main Lighting distribution board (MLDB) shall have MCCB as incomer & outgoing feeder with thermal magnetic release for O/L+S/C+E/F protections.
 - ii. This MLDB shall feed to different Lighting Panels / Lighting DBs for further distribution.
 - iii. Where ever MLDB is not applicable, lighting feeder of appropriate rating shall be derived from the local distribution board. This feeder will feed to local LP catering to lighting requirements of that particular area.
 - b) Constructional Features
 - i. Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP 54 for indoor. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP 55. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2 mm thick.
 - ii. The lighting panel for outdoor lighting shall have a programmable timer for automatic control of lighting along-with contactor, MCB, auto/ manual selector switch.
 - iii. All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets.
 - iv. A slotted metallic sheet shall be provided inside. Only the MCBs operating knobs shall project out of the metallic sheet slots for safe operation and neat appearance. Incomer to lighting panels shall be provided with Four pole MCB + RCCB

- v. All accessible live connections/metals shall be shrouded and it shall be possible to change individual MCBs from the front of the boards/ panels without danger of contact with live metal.
- vi. For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column/structure mounting type panels suitable mounting straps shall be provided.
- vii. Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/bottom entry of cables through glands and or conduits as required. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.
- viii. Two earthing terminals shall be provided to suit the earthing conductor.
- ix. All sheet steel parts shall undergo rust-proofing process which should include 7 tank processing. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final epoxy based finish paint of colour 63I as per IS 5.

c) Busbars

- i. Busbars shall be of copper conductor of hard drawn (HD) and high conductivity.
- ii. Busbars shall be provided with at least the minimum clearances in air as per applicable standards.
- iii. Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the busbars, busbar risers/droppers and contacts does not exceed 85° C under site reference temperature.
- iv. The busbars, busbar connections and busbar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the MCB's let through/cut-off current associated with the specified short-circuit level of the system.
- v. Busbar supports shall be SMC type. Separate supports shall be provided for each phase of the busbars.
- vi. The neutral bus of the main 3 phase, 4 wire distribution board shall be 100% of the phase busbars.

d) Panels/ Boards' Component & Lighting Accessories

i. MCB / ELCB :

- MCBs shall be C curve type for lighting panels.
- For all the lighting panels RCCBs shall be with 100 mA sensitivity & for all receptacles RCBO sensitivity shall be 30 mA.

ii. MCCB :

- MCCB requirements shall be as per specified in the LV switchgear requirements & as specified above.

iii. Indicating Instruments and Meters

- Whenever required, instruments and meters shall be of the flush mounting type. They shall be suitably mounted so as to provide for easy access to CTs and small wiring.
- Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.
- Watt-hour meters shall be of direct reading electro-dynamometer type complete with cyclometer type dials and reverse running stops.
- Ammeter/Voltmeter selector switches having 3 positions and off, with stay-put contacts rated 10A shall be provided when specified.
- Potential fuses shall be provided at the tap-off point from the bus bars for the voltmeters.

iv. Instrument Transformers

- Current and voltage transformers shall be of cast resin type, with insulation class B, & accuracy class 1.0 unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.
- Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short-circuiting and grounding the CTs at the terminal blocks.

- Voltage transformers shall be provided with suitably rated primary and secondary fuses.

v. Indicating Lamps

- Indicating lamps shall be of the clustered LED type, low watt consumption.

vi. Internal Wiring

- Panels/ boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 1.1 kV grade, FRLS PVC insulated, multistranded Copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.
- Cross Ferruling i.e., engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.
- All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make of approved list, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current, the minimum rating shall be 20 A.
- Terminals for circuits with voltage exceeding 125 V shall be shrouded.
- Terminals shall be numbered and provided with identification strip for identification of the circuit.
- Terminal blocks for CT secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

vii. Labels & Diagram Plate:

- All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/ panel.
- Labels shall be made of non-rusting metal, 3-ply lamincoid or engraved acrylic

- Inside the door of the 1 phase ways lighting panels a circuit diagram/ description shall be fixed for reference and identification.

viii. Conduits:

- Rigid steel/ non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.
- Steel conduits shall be seamed by welding and hot dip galvanised. They shall be supplied in standard lengths of 5 metre.
- Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

ix. 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 14 SWG sheet steel 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.
- The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, and HRC fuses as required.
- 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 600 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 painted with one shop coat of red oxide zinc chromate primer followed by a finishing coat of paint.

x. Lighting Poles and Flood Light Pole Mounting:

- Lighting poles for street lights and flood lights shall be of stepped tubular steel poles construction as per applicable standard. These poles shall be coated with bituminous preservative paint on the inside as well as embedded outside surface. Exposed outside surface shall be painted with one coat of red lead oxide primer. After completion of installation two coats of aluminium paint shall be applied.
- Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless otherwise specified, poles shall be painted with red lead oxide primer and two coats of aluminium paint. One steel ladder shall be provided separately. The length of each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm.
- The supply of poles shall be complete with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes.
- The required sizes of poles and the junction box shall be as indicated in the attached drawings.
- Outdoor JB's shall be minimum IP 55 protected.
- Cable entry for street lighting junction boxes shall be from bottom.
- Rain water canopy shall be provided at the top for the outdoor JB's. Terminal strip shall be provided for looping loop out of cables.
- Street lighting JB shall consist of terminal strip (3 ways) for looping in & loop out of cables. The JB shall be provided with 6A MCB (C Curve type) for isolation of lighting fixture, as well as sufficient arrangement (earthing studs) for termination of 2 nos. earthing connections.

xi. 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.
- Exhaust fans, where ever required shall also be provided. The exhaust fan with all parts shall be according to IS: 2312- 1967 & its latest amendment with IP-55

specification. The exhaust fan shall have epoxy powder coating with specially pretreated components for better resistance to corrosion and acid alkali flumes. The exhaust fan shall have totally enclosed highly efficient heavy duty motor with pressure die cast aluminum rotor mounted on two ball bearings.

- The fans shall generally conform to the applicable standards indicated in Tender. Details regarding blade sweep and suspension requirements shall be as per Project layout drawing/price schedule.

4.12 DIESEL STANDBY GENERATOR:

- Applicable Standards : The Diesel Standby Generator and its components shall conform to the latest applicable standards specified below:

Diesel Engines for General Purposes	:	BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	:	BS 5000
Rotating Electrical Machines	:	IS 4722
Circuit breakers	:	IS-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)
Air break switches air break disconnectors, air break switch disconnectors and fuse combination units for voltage not exceeding 1000 V AC or 1200 V DC	:	IS-13947 (P-3), BS-EN60947, IEC-60947-3
Current transformer	:	IS-2705/BS-7626, IEC-60185
Voltage transformer	:	IS-3156/BS-7625/IEC 60186

Electrical Relays	:	IS-3231, 3842/BS-142/IEC-60255
Contactors for voltage not exceeding 1000 V ac or 1200 VDC	:	IS-13947 Part-IV/ BSEN-60947-4-1/ IEC-60947-4-1
Control Switches	:	IS-6875/BSEN-60947 / IEC-60947-4-1
High Voltage Fuse		IS-9385/BS-2692/ IEC-60282
Low Voltage Fuse	:	IS-13703/BS-1362 IEC-269-1
Electrical direct acting indicating instruments	:	IS-1248/BS-89/IEC-6005
A.C. electricity metres of induction type voltage greater than 1000 volts	:	IS722, 8530/BS-5685 / IEC-60145, 60211
Resistance wire, tapes and stripes for heating elements	:	IS-3725
Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes	:	IS-5082
Specification for copper rods and bars for electrical purposes	:	IS-613
Toggle switches	:	IS-3452/BS-3676
Control switches/push buttons	:	IS-6875/BSEN 60947
Noise and Emission Limit	:	As per latest notification of ministry of Environment and

Forests

- General Requirements:

The diesel engine and generator shall be skid mounted and shall be located in a room near Treatment plant substation building. The diesel engine shall draw cooling air directly from outside the room through a weatherproof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel. The silencer shall be of the 'residential' type and be located externally.

The generation voltage shall be 415V for DG capacity less than 2MVA and generation voltage shall be 11kV for D.G capacity more than 2MVA. In case more than one D.G set is required for achieving the required capacity they shall be operated in parallel with necessary synchronizing arrangement. At no point DG sets will be operating parallel with grid.

The diesel engine fuel shall be stored in an above ground bulk storage steel tank to be located adjacent to the generator room at a site accessible for filling to local road tankers. The storage tank shall be sized to store fuel for one (1) day running of the engine at full load. The tank shall be provided with fittings to permit the visual observation of fuel level and filling by local tanker operators. A level meter shall also be mounted in the tank so that remaining fuel volume can be monitored at the generator / substation PLC and the operator stations in the SCADA room.

The fuel storage tank shall be located in a bund capable of holding not less than 125 % of the maximum storage tank contents. Fuel transfer pumps shall be provided to automatically transfer fuel from the bulk storage tank to a high level 990 litres day tank located in the generator room or generator skid mounted day fuel tank. A semi-rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump. Any leakage from the pumps shall be routed to the bund.

A system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally) and if a high level day tank is used, to automatically dump the day fuel back to the bulk storage tank.

The system shall be constructed such that leakage of water, fuel or oil within the generator room shall be routed to a local sump where a detector shall be provided to raise an alarm.

The system shall be constructed such that the leakage of fuel or the accumulation of water within the fuel storage bund shall be detected and shall raise an alarm.

All alarms shall be conveyed to the central HMI through the PLC.

- Diesel Generating Set Automatic Control

AMF Diesel Generator Set capable of automatic starting and picking the load within 30 seconds shall be provided to cater for emergency loads and lighting during mains power failure. Diesel generating set for use in auto mains failure mode shall have a three position automatic / off / manual selection and shall operate as follows:

(i) Automatic mode :

On occurrence of mains failure the following sequence shall be followed.

Mains to Generator changeover

- mains failure detected
- delay of 10 seconds
- generator is started and run up to speed
- time delay of 50 seconds
- mains supply is switched off
- generator supply is switched on

Generator to Mains changeover

- mains healthy detected
- manual changeover signal received,
- generator supply is switched off

- mains supply is switched on
- generator runs for 2 minutes and stops
- All timer settings shall be adjustable.

If mains power is restored during the initial one minute delay then the power shall be monitored for a further one minute and if it is still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after three attempts the system shall shut down and a local and remote alarm shall be annunciated.

(ii) Manual mode:

The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

- Alternator for Diesel Generating Set:

The generation voltage shall be 415V for capacity less than 2MVA and generation voltage shall be HV for capacity more than 2MVA.

Alternator shall be 4 pole, 3 phase, 50 Hz, 0.8 P.F, salient pole, revolving field, brushless type, self-regulating continuously rated and manufactured in accordance with IS 4722, BS 5000 : Part 99 or IEC 60034-1. They shall be totally enclosed, screen protected, fan ventilated and vertical drip-proof conforming to IP 23. The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects. The terminal box shall be dustproof with IP 54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved. Alternators shall be capable of withstanding a 10% overload for 1 hour in any 12 hour Period under the specified conditions of temperature, humidity and atmospheric pressure.

Alternator windings shall be of Class H insulation with Class F temperature rise and tropicalised. The alternator shall have pre-packed grease lubricated ball or roller bearings and provided with facilities for regreasing whilst in service.

The alternator shall be foot mounted on a common bed frame with the prime mover close coupled to the engine flywheel housing. The direction of alternator rotation when viewed from the driven end shall be clockwise and phase voltage sequence UVW. The alternator vibration level shall not exceed the values defined in IS 12075.

The alternator shall be capable of maintaining a short circuit current of three times full load current for a period of 10 seconds. The alternator shall be fitted with an anti-condensation heater. No individual harmonic shall exceed 1% and the total harmonic shall not exceed 3%. The alternator, its neutral and control panel shall be earthed as per relevant standards.

The alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier surge protection device and salient pole rotating field system. The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained to within $\pm 2.5\%$ for a power factor of 0.8 to unity, including hot to cold variations. The steady state frequency droop between no load and full load shall not exceed 5%. Transient voltage deviation following a step load of 60% of rated at a power factor of between 0.4 and zero shall not exceed 15% with a voltage recovery time to 97% rated voltage not exceeding 0.5 second. The set shall be capable of continuous operation with a phase current imbalance of 33% of rated current whilst maintaining the output voltage within $\pm 5\%$ of rated.

- Diesel Engine for Generating Set:

Engine shall be four stroke, direct injection, turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate.

Engines shall be rated for continuous duty at site ambient conditions with an inherent O/ L Capacity of 10% for 1 hour in any 12 hours. The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10000 hours between major overhauls. The maximum operating speed shall be 1 500 rpm. The range of manual adjustment shall not be less than $\pm 5\%$ of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.

Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical over speed trips, there shall be a mechanical device which shall operate at 120% of the rated speed. Re-setting of the over speed trip shall be possible by hand only. The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%. Engines shall be designed to run on fuel oil complying with IS 1460 or BS 2869, Class A2. Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it is located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by- pass valve shall be incorporated. Engine lubrication shall be by a closed circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer. The starting system shall comprise 12 or 24 V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at 0°C. An engine driven alternator and charging system shall be provided. An automatic mains energised battery charger shall be

provided, with sufficient capacity to maintain the battery in a condition to fulfil the starting requirements. Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that normal starting of the engine is inhibited whilst the hand turning equipment is connected. Twin heavy duty air intake filters in accordance with IS 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbocharger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.

Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250 kVA), water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion.

Machined surfaces shall be incorporated for mountings and for levelling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for leveling purposes and shall be designed to resist horizontal movement of the diesel set.

The fuel System shall comprise an engine driven feed pump with duplex filters, 990 litres day tank with supporting structure or generator skid mounted day fuel tank, with all interconnecting pipe work, flexible engine connection pipe etc.

- Diesel Generator Control Panel:

The control panel shall be separately mounted on anti vibration mountings and shall

Comprise the following:

- Breaker incorporating short circuit and overload trip
- Earth fault protection for the Alternator
- Alternator Over & Under Voltage Protection
- Voltage Controlled Over Current Relay
- voltmeter and seven position selector switch

- ammeter and 4 Position selector switch
- frequency meter
- Power Factor Meter
- Kwh Meter
- engine temperature and oil pressure gauge
- service hours run indicator
- key switch start and stop control
- operational status indicator
- anti-condensation heater and thermostat
- alternator anti-condensation heater controls
- mains fed battery charger
- Auto start on mains power supply failure facility
- Fails to Start (Alarm)
- Over / Under Voltage Alarm
- Battery Charger Fault (Alarm)
- Low fuel Oil Level (Alarm)
- Over Load (Alarm)
- Low Lube Oil Pressure (Trip)
- High Water Temperature(Trip)
- High Lube Oil Temperature (Trip)
- Electrical Protection Relays (Trip).

A reset button shall be provided to cancel the alarm /shut-down condition prior to re-starting.

Simple operating instructions shall be detailed on the fascia of the control panel.

- Synchronizing Panel

Whenever two sets are required to operate together, necessary synchronising panel complete with circuit breaker, synchroscope, relays, meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

- Acoustic Enclosure

- a) The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.
- b) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire retardant foam /glass wool as acoustic material.
- c) The sound level shall be restricted to 75 dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.
- d) The acoustic enclosure shall be certified to meet the emission norms.

- Bulk Fuel Storage Tanks

Tanks and fittings, etc shall conform to IS 803 or BS 799: Part 5. The tank shall be constructed in mild steel and the fittings in materials other than:

- Yellow brass, including low grade alloys of copper and zinc.
- Lead and zinc.
- Galvanised metals.
- Natural rubber.

An ullage volume above maximum contents level of the tank shall not be less than 5% of the maximum volume of the fuel. The maximum fuel surface level below the point of entry of the vent shall not be less than 100 mm. The internal surface shall be cleaned and treated with temporary preservative, soluble in fuel oil, before shipment.

The following fittings shall be included:

- (a) 600 mm diameter manhole complete with portable cover situated in the top of the tank complete with ladder to the interior.
 - (b) Dipstick, calibrated in litres with guide tube and striker plate.
 - (c) Local indication of fuel level to be given at a position where it can be easily read during fuel delivery.
 - (d) Filling pipe work and fittings complete with isolation valve and captive end cap. The filling point to be at the top of tank to prevent siphoning.
 - (e) Outlet pipe situated at the raised end of the tank not less than 150 mm above tank bottom, complete with check valve, isolating valve and end cap.
 - (f) Drain pipe situated at lowest point in tank complete with isolating valve and captive end cap.
 - (g) Inlet fittings for overflow pipe from daily service tank or tanks (where specified).
 - (h) Vent pipe situated at high level in the tank. The pipe shall rise continuously from the tank and terminate with an inverted 'U' bend and vermin screen.
 - (i) External ladder for horizontal tanks more than 2 m diameter.
- Drawings / Documents Required:

All Drawings, data, technical particulars, calculations, detailed literature, catalogues Test certificates etc shall be submitted along with the bid/ after award of contract

1.5 SAFETY EQUIPMENTS / REQUIREMENTS AND MISCELLANEOUS ITEMS:

Following safety procedure and practice should be provided by Contractor in switchgear room/ sub-station as per latest edition of I.S. 5216.

- a) 900 mm wide antiskid insulating mat as per IS 15652 and of reputed make to be spread in front of the HV panel, 415V switch gear panels & power DBs, DCDB etc.
- b) First aid box with all the standard contents.
- c) First aid chart made of cloth for electrical shock treatment printed in English, Hindi and Gujarati duly framed with front glasses.
- d) Charts / drawings duly framed with front glass.
- e) Single line diagrams in adequate sizes approved by Purchaser's representative & in line with the local electrical inspector
- f) Routine maintenance schedule for High Voltage Switchgear, Distribution Transformers, Low voltage Switchgears, APFC panels, Fire Alarm System, UPS system etc.
- g) Provision of portable type Class A, B, C, and D type fire extinguishers at various locations in line with the statutory requirements.

1.5.1 Fire Safety:

- a) The requirement of hand appliance in switchgear room, electrical equipment room shall be provided as per Clause 4.0 of Fire Protection Manual by Regional Tariff Committee, 10th edition 1988.
- b) Water Sealing & Fire Barriers at appropriate locations as specified in this specifications & good engineering practices.

1.5.2 Degree of Protection:

- a) The enclosures of the control cabinets, junction boxes and Marshalling boxes, panels etc. to be installed shall provide minimum degree of protection as detailed here under
 - i. Installed outdoor - IP 55.
 - ii. Installed indoor - IP 54

- b) The degree of protection shall be in accordance with IS 13947 (Part I)/ IEC 947 (Part I)/ IS 2063/ IEC 529

1.5.3 Electrical Equipment For Hazardous Areas:

The electrical equipments for hazardous areas shall be selected as per IS 5572. Following factors shall be considered for proper selection of electrical equipments for use in Hazardous Area.

- a) Area Classification (Zone)
- b) Gas Classification (Group) – The characteristics of the gas or vapour involved in relation to the ignition or energy and safe gap data
- c) Temperature Classification- The ignition temperature of the gas or vapour involved or lowest value of the ignition temperature, if more than one combustible material is present.
- d) Environmental conditions – In which apparatus is to be installed. The selected electrical apparatus shall be adequately protected against corrosive and solvent agencies water ingress, thermal and mechanical stresses as determined by the environmental condition

1.6 INSTALLATION, TESTING & COMMISSIONING – ELECTRICAL EQUIPMENT:

In accordance with the specific installation instructions, as shown in Contractor's drawings or as directed by the Engineer's Representative the Contractor shall unload, erect, install, wire, test and place into commercial use of all electrical equipment included in the contract. Equipment shall be installed in a neat manner so that it is level, plumb, and properly aligned and oriented.

The Contractor shall furnish all supervision, labour, tools, equipment, rigging materials and incidental materials such as bolts, wedges, anchors, concrete inserts etc. required to completely install, test and adjust the equipment.

Drawings, instructions and recommendations shall be correctly followed in handling, settling, testing and commissioning of all equipment and 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.

The Contractor shall erect and commission the equipment as per the instructions of the Purchaser/ Purchaser's Representative and shall extend all co-operations to him.

In case of any doubt/ misunderstanding as to correct interpretation of drawings or instructions, necessary clarification shall be obtained from the Engineer's Representative. The Contractor shall be held responsible for any damage to the equipment consequent to not following instructions correctly.

The Contractor shall move all equipment into the respective buildings through regular doors or floor openings provided specifically for the equipment. The Contractor shall make his own arrangement for lifting of equipment.

Where assemblies are supplied in more than one section, the Contractor shall make all necessary mechanical and electrical connections between sections including the connections between busbars/wires. The Contractor shall also carry out the adjustments/alignments necessary for proper operation of the circuit breakers. All insulators and bushings shall be protected against damage during installation. Insulators or bushings chipped, cracked or damaged due to negligence or carelessness shall be replaced by the Contractor at his own expenses.

The Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments or relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. The blocking material/mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels 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 Engineer's Representative.

Inspection, storage, installation, testing and commissioning of transformers shall be in accordance with the latest Indian Standards Code of Practice IS: 10028. All commissioning tests as applicable, vide Appendix B of IS: 10028 (Part II) shall be carried out. Fire Wall of 4 Hr fire rating shall be provided between two transformers.

Switchgear control panels shall be installed in accordance with the latest Indian Standard Code of Practice 10118. The switchgear panels shall be installed on finished surface or concrete or steel sills. The Contractor shall be required to install

and align any channel sills which form part of the foundations. Tape or compound shall be applied where called for. The base of outdoor type units shall be sealed in an approved manner to prevent ingress of moisture.

Following minimum clearances shall be observed while finalizing the electrical panel layouts-

- a) Minimum clearance of 1 meter shall be maintained from the rear of the panel to the nearest wall /structure.
- b) Minimum clearance of 2 meters between panels facing opposite to each other.
- c) Side clearance for LV panels shall be either $\leq 200\text{mm}$ or $\geq 800\text{ mm}$.
- d) For HT metal enclosed, indoor panels, Minimum 1 meter clearance from all sides & 1.5 meter in the front.
- e) Emergency Exit doors shall be provided for electrical room, complying with the requirements of NBC 2005 latest edition.

After installation of all power and control wiring, the Contractor shall perform operating tests on all switchgear and panels to verify the proper operation of switchgear/panels and the correctness of the interconnections between various items of equipment. This shall be done by applying normal a-c or d-c voltage to the circuits and operating the equipment. Megger tests for insulation, polarity checks on the instrument transformers, operation tests on equipment, and installation tests shall be carried out by the Contractor who shall also make all necessary arrangements for proper functioning of the equipment.

Equipment furnished with finished coats of paint shall be touched up by the Contractor if their surface is spoiled or marred while handling.

Foundation work and grouting of fixing bolts or channels for all transformers, switchgear, motors, and control panels shall be carried out by the Contractor.

1.6.1 Earthing And Lightning Protection System

- The Contractor shall install copper/ steel conductors, braids, etc., required for the system and individual equipment earthing. All work such as cutting, bending, supporting, painting/coating, drilling, brazing/soldering/welding, clamping, bolting and connecting 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, bituminous compound, welding rods, 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 quantities, sizes, material of earthing conductors and electrodes to be installed as per requirement. Routes of the conductors and locations of electrodes shall be shown in the earthing layout drawings, which are to be prepared by Contractor & approved by Purchaser's representative.
- The work of embedment of earthing conductor in RCC floors/walls along with provision of earth plate inserts/pads/earth risers shall be done by the Contractor when the floors are cast or during construction of walls. Contractor's scope of installation shall also include, laying the conductors in position with 60 mm concrete cover, making welded connections to inserts/pads/risers above the floor near the equipments. The embedded conductors shall be connected to reinforcing rods wherever necessary.
- If the tap connections (earthing leads) from the floor embedded main earthing grid to the equipment are more than 500 mm long then the same shall be embedded in floor by the Contractor where required, together with associated civil work such as excavation/chasing, concreting and surfacing. The concrete cover over the conductor shall not be less than 60 mm.
- Installation of earth conductors in outdoor areas, buried in ground, shall include excavation of earth up to 600 mm deep 450 mm wide, laying of conductors at 600 mm depth, brazing/welding as required, of main grid conductor joints as well as risers of length 500 mm above ground at required locations and then 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 utilizing pneumatic tampers or other approved means. If the excavated soil is found unsuitable for backfilling, the Contractor shall arrange for suitable material from outside.
- 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 grids risers, bolting at equipment

terminals and coating welded/brazed joints by bituminous paint. Galvanized conductors shall be touched up with zinc rich paint where holes are drilled at site for bolting to equipment/ structure.

- Electrodes shall be installed in constructed earth pits, and connected to main buried earth grid, The scope of work shall include excavation, construction of the earth pits including all materials required for construction of earth pits, placing the rod and fixing test links on those pipe/rod/plate electrodes in test pits and connecting to main earth conductors.
- Installation of lightning conductors on the roofs of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying fastening/ cleating/ welding of the down comers on the walls/columns of the building and connection to the test links to be provided above ground level.
- 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.
- Whenever main earthing conductor crosses cable trenches, they shall be buried below the trench floor.
- Suitable earth risers shall be provided above finished floor/ ground level. If the equipment is not available at time of laying of the main earth conductors, the minimum length of such riser inside the building shall be 200 mm and outdoors shall be 500 mm above ground level. The risers to be provided shall be marked in project drawings.
- Earth leads and risers between equipment earthing terminals and the earthing grid shall follow as direct and short a path as possible.
- An earthing mat shall be provided under each operating handle of the isolator and operating mechanism of HV breakers. Operating handle of the isolator and supporting structure shall be bonded together by a flexible connection and connected to the earthing grid.
- A separate earth electrode bed shall be provided adjacent to structure supporting lightning arrestors. Each connection shall be as short and as straight as practicable.

For arrestors mounted near transformers, earth conductors shall be located clear off the tank and coolers.

- Wherever earthing conductors passes through walls, galvanized iron/PVC sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Contractor by suitable water proof compound.
- Earthing Connections
 - a) All connections in the main earth conductors buried in earth/concrete and connection between main earthing conductor and earth leads shall be of welded type.
 - b) Connection between earth leads and earthing terminal provided on the equipment shall be bolted type.
 - c) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
 - d) Metallic conduits and pipes shall be connected to the earthing system.
 - e) Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. Also no intermediate earthing connection shall be made to lightning arrester and transformer earthing leads which shall be directly connected to pipe electrode.
- Earth Electrodes
 - a) Electrodes shall as far as practicable, be embedded below permanent moisture level.
 - b) Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of pipe electrodes in test pits shall be suitable for watering. The necessary materials required for installation of test pits shall be supplied and installed by Contractor. The installation work shall also include civil work such as excavation and connection to main earth grid.
 - c) Earth pits shall be treated with salt and charcoal. In case found necessary, then with the approval of Purchaser's representative, Back fill compound of suitable composition may be used. Back fill material shall not be water soluble & shall retain moisture & enhance conduction around electrode. Back fill compound shall be low

resistance & non corrosive earth enhancement compound which shall provide safe discharge path to fault current & lightening current.

- d) Ohmic value shall be within safe limits & it shall be stable & not fluctuating.
- e) Soil, salt and charcoal placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in layers of 250 mm thick uniformly spread and compacted. If excavated soil is found unsuitable for backfilling, the Contractor shall arrange for a suitable soil from outside.

1.6.2 Installation of Cable Racks And Cable Trays :

- Lines and grade for trays may be measured from building steel and finished floor elevations. Change in line or grade, or the addition of offsets by means of cutting standard tray sections and inserting additional tray fittings to match with the existing arrangement shall be considered as a normal part of the work.
- Where embedded steel inserts in concrete floors/ walls for welding the supports for cable racks/ trays are not available, Contractor shall provide suitable anchor fasteners at no extra cost.
- Cable shall be clamped to the cable trays at every 750 mm distance.
- Flexible metallic conduits shall be used for termination of connection to equipment such as motors, limit switches and other apparatus.

1.6.3 Cable Installation

- General
 - a) Cable installation shall be in accordance with IS 1255: 2001- latest edition.
 - b) Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.
 - c) Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.
 - d) Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cable.

e) Table of Separation Distances in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/ Protection	Tele-communication
HV Power	N/A	300	400	400
LV Power	300	N/A	300	300
C&I/ Protection	400	300	N/A	200
Tele-communication	400	300	200	N/A

- f) These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.
- g) Minimum Clearance of 300mm shall be kept between any other utility & power cables.
- h) In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.
- i) Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.
- j) Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation as per indicated in above

table shall be maintained between power and non-power cables when run on the same support system.

k) Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. FRP/ GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

- Instrumentation Cabling:

a) In order to make the most economic use of cable ladder/tray and duct capacity, multicore cabling shall be utilized in order to connect instrumentation groups by using suitably located sub-distribution junction boxes. The junction boxes shall be suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labeled junction boxes shall be constructed of die cast Aluminium and provide degree of protection IP 65.

b) Separate cables shall be used for digital and analogue signals at all times.

c) Instrumentation cables shall be continuous without any joints.

d) Digital and analogue signals shall be segregated within junction boxes.

- Cables Laid Direct in Ground

a) Buried cable up to 1.1 kV shall have a laid at a minimum depth of 750 mm measured from FGL to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete.

b) Cables of greater than 1.1kV shall be buried at a minimum depth of 1 meter.

c) The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable. For HT cables sand bedding shall be of 150 mm & cables shall be covered with half round Hume pipes of twice the diameter of cable.

d) Interlocking cable protective covers, minimum 1 m long x 300 mm wide, marked 'Danger-Electric Cable' in English and the vernacular shall be laid on top of the

sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm.

e) Warning tape shall be laid a minimum of 200 mm above the protective covers.

f) Cables are to be installed without tees or through joints unless otherwise approved by the Purchaser's Representative. Single core cables shall be run in trefoil formation.

- Cables Laid in Underground Ducts

a) Underground ducts shall be constructed of impact resistant PVC-U and laid at a minimum depth of 750 mm, ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1 meter deep and encased on all sides by 150 mm of concrete.

b) The Contractor shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.

c) Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Purchaser's Representative. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated. However, for two different trefoil formations, they shall be laid in separate ducts.

- Cables installed in Conduit

a) Conduits shall be galvanized heavy gauge solid drawn or welded screwed steel type and be in accordance with IS 9537 Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanized.

b) A space factor of 40% shall not be exceeded, but in any case conduit of less than 20 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.

- c) Where a number of conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.
- d) Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/ or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.
- e) Heavy hexagonal lock nuts shall be used at all positions where running joints are required and care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.
- f) Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Purchaser/ Purchaser's Representative.
- g) Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc. and covers, either temporary or permanent, shall be fitted on all boxes.
- h) Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.
- Surface Installation
 - a) Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips at every 500mm, which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Purchaser's Representative before the installation is carried out. Where large multiple parallel conduit runs

would occur, use may be made of galvanized cable trunking. Conduits installed on structural steelwork shall be secured at spacing not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Purchaser's Representative. Any drilling or access which is required through any structural member of the building shall be agreed with the Purchaser's Representative before carrying out the work.

- b) Exposed threads and places where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

- Concealed Installation

- a) Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crumpets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.
- b) At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.
- c) Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.
- d) The conduit installation shall be inspected by the Purchaser's Representative before the building operation conceals the work.

- Cable Installed in Flexible Conduit

- a) Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it

is attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

- b) Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

- Cable Installed in Cable Trunking - Metal

- a) Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50 mm x 50 mm minimum size.
- b) Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.
- c) The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self retaining 'quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.
- d) Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.
- e) Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

- f) Trunking shall be supported at intervals not greater than 2 meter horizontally or 2.5 meter vertically.
- g) Crossings over expansion joints shall be made in flexible conduit.
- h) Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.
- i) Cable and conduit/ trunking runs shall be determined by the Contractor and agreed by the Purchaser's Representative before any work is started. The run shall be at least 300 mm clear of plumbing and mechanical services.
- j) Conduit/ trunking systems erected outside a building shall be weatherproof.
- Cable Installed on Cable Tray: All the cable tray shall be hot dipped galvanized with minimum galvanization thickness as per mentioned in this specifications.
 - a) Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1.25 mm for trays up to 100 mm width, not less than 1.5 mm for trays from 100 mm to 150 mm width and not less than 2 mm for trays from 150 mm to 300 mm width.
 - b) All the cable trays above 300 mm width shall be of ladder type with minimum thickness of 2.5 mm.
 - c) Cable tray for use in areas where chlorine gas may be present shall be constructed from U-PVC or GRP. Cable tray supports shall be of a compatible finish with the associated cable tray.
 - d) All cable trays tees, intersection units, bends, turns and sets shall be prefabricated (made by the manufacturer) and shall be of a matching design to the main section of cable tray.
 - e) Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer's instructions.
 - f) Cable tray supports supplied by a manufacturer or made up on Site shall have adequate strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid span.

- g) Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanized paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.
- h) All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Purchaser's Representative, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid span. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kgs.
- i) Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray
- j) The sizing of the cable tray shall provide a minimum of 20% spare capacity.
- k) The tray shall be run at least 300 mm clear of plumbing and mechanical services.
- l) Bends in the installation shall take account of the minimum bending radii of cables to be installed.
- m) All the cable trays shall be supplied with cable tray supports (of adequate size) at no more than 1.2 meter interval.
- n) Other cable tray details & cabling system shall be as per typical drawings attached with the specifications.
- Cable Clipped Direct

All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed. Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.
- Cable Installed in Internal Floor Trench
 - a) In shallow trenches (maximum depth 500 mm)

- b) In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an acceptable manner & such a way that, in no case the distance between two different types of cable shall not be less than the separation distance tabulated above.
 - c) Where the trench is shared by other services, cables shall be installed on the walls of the trench in an acceptable manner & such a way that, minimum separation distance of 300mm shall be maintained.
 - d) All other trenches including walk through service ducts
 - e) Cable trenches & cable installation shall be in accordance with the attached typical cabling system drawings.
 - f) Where other services are present the cables shall be segregated from them by separation distances as mentioned above and wherever possible kept above 'cold' wet services. Cables should not be run if at all possible above or in close proximity to 'hot' services.
 - g) The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation
- Cable Terminations and Joints
 - a) Power Cable Terminations
 - b) Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors.
 - c) Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.
 - d) Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.

- e) Adequate provision shall be made to bond the cable armouring to the box and/or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box is not possible.
 - f) Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.
 - g) Where terminations of multicore type have to be made on to items of Plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.
 - h) Where single core cables are glanded to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.
- Power Cable Joints
 - a) Through joints shall only be allowed with the approval of the Purchaser's Representative. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall preferably be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Purchaser/ Purchaser's Representative prior to filling the box with compound. Wrapped pressure type joints will not be accepted.
- Multi-core or Control Cable Terminations
 - a) A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.
 - b) Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.
 - c) Terminals which remain energized when the main equipment is isolated shall be suitably screened and labeled.

- d) Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labeled.

- Cable Fixings

- a) Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing.

- b) Large single cables shall be secured with cable clamps or cable cleats.

- Cable Identification

At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Purchaser's Representative. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

- Marking Locations of Underground Cables

- a) The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.
- b) Cable route markers as per the attached drawing shall be installed at an interval not more than 30 meter & at bending / road crossings the interval shall be at every 10 meter.
- c) The minimum depth for laying of underground cable route markers shall be as per indicated in the typical drawings attached with this tender.

- Additional Requirements for Cable Installations

- a) The Contractor shall install, test and commission the cables specified in the specification. Cables shall be laid directly buried in earth, on cable racks, in built up trenches, on cable trays and supports, in conduits and ducts or bare on walls,

ceiling etc. as per drawings, which are to be prepared by Contractor & approved by Purchaser's representative. Contractor's scope of work includes unloading, laying, fixing, jointing, bending, and termination of the cables & all related accessories. The Contractor shall also supply the necessary materials and equipment required for jointing and termination of the cables.

- b) All apparatus, connections and cable work shall be designed and arranged to minimize risk of fire and any damage which might be caused in the event of fire. Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall be supplied and put into position by the Contractor.
- c) Standard cable grips and reels shall be utilized for cable pulling. If unduly difficult pulling occurs, the Contractor shall check the pull required and suspend pulling until further procedure has been approved by the Engineer's Representative. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering and does not set up undesirable conditions of electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduits and ducts.
- d) After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags. Identification tags shall be attached securely to each end of each cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags shall further be attached at 10 meter intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required.
- e) Sharp bending and kinking of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified below:
 - i. 11 kV, XLPE insulated, multicore : 15 times the overall dia of the cable
 - ii. armoured cables
 - iii. 1.1 kV, XLPE insulated, multicore : 12 times the overall dia of the cable
 - iv. armoured cables

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- v. (If shorter radius appears necessary, no bend shall be made until clearance and instructions have been received from the Purchaser/ Engineer in charge)
 - f) Power, control and instrumentation cables shall be laid in separate cable racks/trays.
 - g) Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to segregate them physically shall be provided.
 - h) Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in reinforced spun concrete or steel pipes. For road crossings the pipe for the cables shall be buried at no less than one meter depth.
 - i) Cables laid in ground shall be laid on a 75 mm riddled earth bed. The cables shall then be covered on top and at their sides with riddled earth of depth of about 150 mm. This is then gently filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which are placed centrally over the cables. The protective cable covers for LV cables may be of earthenware and for HV cables of reinforced concrete. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench is then backfilled with the excavated soil and well rammed in successive layer of not more than 300 mm in depth, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, it is advisable to allow a crown of earth not less than 75 mm in the centre and tapering towards the sides of the trench.
 - j) In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop a fault at a later date.
 - k) Cables on cable racks, on cable trays and conduits shall be formed to avoid bearing against edges of trays, racks, conduits or their supports upon entering or leaving trays, racks or conduits. Cables shall be racked or laid directly into cantilevered cable trays where practicable, but in some cases it may be necessary that cables are pulled or threaded into trays. To facilitate visual tracing, cables in trays shall be laid only in single layers and unnecessary crossing of cables shall be avoided. Cables on trays shall finally be clamped in an approved manner.
 - l) Cable splices will not be permitted except where permitted by the Purchaser/ Purchaser's Representative. Splices shall be made by Contractor for each type of
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wire or cable in accordance with the instructions issued by cable manufacturer's and the Engineer's Representative. Before splicing, insulated cables shall have conductor insulation stepped and bound or penciled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.

- m) Jointing of cables shall be in accordance with relevant Indian Standards Codes of Practice. Materials and tools required for cable jointing work, including cold setting bituminous compound shall be supplied by the Contractor. Cables shall be firmly clamped on either side of a straight through joint at a distance of not more than 300 mm away from the joints. Identification tags shall be provided at each joint at all cable terminations.
- n) At cable terminal points where the conductor and cable insulation will be terminated, terminations shall be made in a neat, workmanlike and approved manner by men specialized in this class of work.
- o) Control cable termination shall be made in accordance with wiring diagrams, using colour codes established by the Purchaser's Representative for the various control circuit, by code marked wiring diagram.
- p) When control cables are to be fanned out and cabled together with cord, the Contractor shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any question as to the proper connection, the Contractor shall make a temporary connection with sufficient length of cable so that the cable can be switched to another terminal without splicing. After correct connections are established through operating the equipment, cables shall be cut to their correct lengths, connected to terminals in the specified manner, and corded together where necessary to hold them in place in a workmanlike manner.
- q) Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing by the Purchaser/ Purchaser's Representative. Before jointing is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.

- r) After installation and alignment of motors, the Contractor shall complete the conduit installation, including a section of flexible conduit between motor terminal box and trench/ tray. The Contractor shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings.
- s) Metal sheath and armour of the cable shall be bonded to the earthing system of the station. The size of conductor for bonding shall be appropriate with the system fault current.

1.6.4 Lighting System Installation:

- This covers the requirements of installation of the following:
 - a) Lighting fixtures complete with lamps and accessories
 - b) Main Lighting distribution board
 - c) Lighting panels
 - d) Receptacles and lighting control switches
 - e) Point wiring
 - f) Street lighting poles and flood light towers
 - g) Multi core cables for street and boundary lighting
 - h) Maintaining equipment/ materials during storage and being responsible for the equipment/ material until they are handed over to Purchaser.
 - i) Installation, testing and commissioning shall be carried out in accordance with the drawings and as stipulated in this specification.

- Applicable Standards

Electrical wiring installations : IS: 732

(System voltage exceeding 650 V)

Code for practice for interior illumination (Part-1) : IS: 3646/ BS: 8206

Code of practice for street lighting installation : IS: 1944

Code of practice for industrial lighting : IS: 6666

Code of practice for fire safety of building	:	IS: 1646
Boxes for enclosure of electrical accessories	:	IS: 5133(Part-1)
Guide for safety procedures and practices in electrical work	:	IS: 5216
Ceiling roses	:	IS: 371
LED modules for general lighting-Safety Requirements	:	IEC 62031
Fixed general purpose luminaries	:	IEC 60598-2-1
Luminaire - General requirement and tests	:	IEC 60598-1
Lamp control gear : particular requirements for DC or AC supplied electronic control gear for LED modules	:	IEC 61347-2-13
LED luminair photometry measurement	:	LM 79
Self-ballasted LED lamps for general lighting services- Performance requirements	:	IEC/PAS 62612
Self- Ballasted LED Lamps for General Lighting Services-Part 1 Safety	:	IS 16102(Part 1) : 2012
General Lighting - LEDs and LED modules – Terms and Definitions	:	IS 16101 : 2012
Self-Ballasted LED Lamps for General Lighting Services Part 2 Performance Requirements	:	IS 16102(Part 2) : 2012

- Lighting Fixtures

- a) The installation of lighting fixtures shall be based on the approved mounting arrangement. The rates quoted for installation shall include all materials required to mount the fixtures. Hooks in RC slabs for suspension of high bay fixtures shall be provided wherever not already provided. Cost of supply and installation of such hooks shall be included in the cost of installation of lighting fixtures. Rate for installation of lighting fixtures shall include cost of installation of control gear box wherever applicable.
- b) Installation of receptacles and switches shall be carried out suitably. Switch shall be mounted in flush with the front cover plate. Cost of supply and installation of necessary hardware shall be included in the lump sum rates quoted for installation of receptacles/ switches.
- c) Lighting distribution boards shall be installed at the suitable location. Installation shall include supply and installation of base channels, foundation bolts, etc.
- d) Outdoor lighting distribution boards shall be installed on a concrete plinth. The top of plinth shall be 1000 mm (min.) above the grade level. Cost of construction of concrete plinth shall be included in Contractor's scope. No cement and steel will be supplied by Purchaser. Installation cost of lighting distribution board shall include cost of installation of earthing conductor from LDB to the nearest earthing grid.

- Point Wiring

- a) Contractor has to prepare the detailed conduit layout drawing showing primary & secondary point wiring points. Point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches of receptacle units.

- i. Primary Point Wiring

Primary point wiring covers the wiring between a circuit of the lighting panel to the junction box of the first lighting fixture/receptacle unit and between junction boxes of the subsequent lighting fixture 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/receptacle unit in that circuit.

ii. Secondary Point Wiring

Secondary point wiring covers the wiring of the remaining lighting fixtures/receptacle unit other than that covered under primary point of that circuit in the lighting panel. Secondary point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches and control switches of receptacle units.

b) Supply and Installation of Conduit Point Wiring

- i. The point wiring shall include supply of necessary materials for the conduit wiring such as galvanized rigid steel conduit, galvanized M.S. fixing saddles with spacer plates, nylon/fiber fixing plugs, galvanized M.S. fixing screws, 12 SWG galvanized steel earthing wire, FRLS PVC insulated Copper conductor wires, control switches and pulling, termination of the earthing/ FRLS PVC insulated wires 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.
- ii. Wires used for conduit point wiring of lighting fixtures/ceiling fans, 5A receptacles and receptacles above 15A shall be 1.1 kV grade, FRLS PVC insulated, single core, multistranded Copper conductor wires of sizes not less than 1.5 sq. mm and 2.5 sq. mm respectively. Wires shall conform to IS: 694 and shall bear the ISI mark.
- iii. Contractor shall take into consideration necessary galvanized MS fixing clamps when the wiring conduits are to be supported from steel roof truss/structural members.

c) Supply & Installation of cabling for Street and Flood Lighting

- i. Work includes supply and installation of cables required between LDB and junction box mounted on street lighting pole/flood lighting tower and also between junction box mounted on flood light tower to metal enclosed control gear box located near flood light fixture, supply and installation of all the termination accessories such as crimping type cable lugs and double compression 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 HDPE / Hume pipes for road crossing, etc, supply and installation of necessary cleating arrangement for cabling on flood light tower, supply of labour, supervision, welding equipment, all tools and tackles and testing equipment as required.

- ii. Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary the same shall be provided by the Contractor and a joint marker shall also be provided at no extra cost. Earthing of street light pole/flood light tower, lighting fixtures, etc. are included under Contractor scope.

d) Point wiring shall also include/hold good for the following :

- i. Supply and installation of lighting control switches and switchboxes complete with fixing accessories.
- ii. Drilling holes in brick/RCC wall and roof for taking cable or conduit, sealing and refinishing with cement plaster.
- iii. Testing, commissioning and handing over the lighting system in commercial working condition.
- iv. Marginal shifting of any fixture/accessory from the location indicated in the lighting layout drawings.

- Outdoor Lighting (Street and Flood Lighting) : The following shall be deemed to be included as part of the installation work for outdoor lighting point wiring.

- a) Installation of multicore/ single core cables between LDB and junction box mounted on street light pole/flood lighting tower, from junction box to metal enclosed control gear box.
- b) Supply and installation of crimping type cable lugs, double compression type cable glands at each junction box and fixture, termination, testing and commissioning of cables.
- c) Contractor's scope shall also include excavation and preparation for buried cables. Supply and installation of route markers, supply and installation of

HDPE/Hume pipes for road crossing shall also be included in the scope of installation of point wiring.

- d) Supply and installation of necessary cleating arrangement for cabling on flood light poles.
 - e) Contractor shall provide necessary foundation for erecting street light pole/flood light tower and install the same. Contractor shall prepare foundation drawings with necessary details & Purchaser Representative's approval shall be obtained.
 - f) Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary, the same shall be provided by the Contractor and joint marker shall also be provided at no extra cost.
 - g) Earthing of street light pole/flood light tower, lighting fixtures, control gear boxes, junction boxes, etc. are also included in the scope of installation of point wiring. Contractor shall earth street light pole/flood light poles and junction box with 25x3 mm G.S. flat tap off from the 25x3 mm M.S. flat earthing grid along the street lighting included in scope. The Contractor shall interconnect earthing grid to plant main earthing grid at first and last pole of each feeder circuit and at one intermediate poles.
 - h) Installation of lighting Poles and Towers for Outdoor Lighting (Street and Flood Lighting)-
 - i. Work includes supply and installation of street light poles and flood light towers including associated junction boxes with fuses, links and terminals for junction boxes and junction boxes near each flood light fixtures.
 - ii. All street light poles and towers shall be painted with one shop coat of red oxide oil primer followed by two coats of aluminium alkyd paint.
- Installation of Lighting Distribution Board, Lighting Panels (AC & DC), 230 V, AC 1-Ph Distribution Boards.

Installation of above items shall include necessary foundation channels, bolts/ nuts, etc. for grouting lighting distribution boards, iron brackets/ grouting brackets, bolts/nuts for wall/ column mounted panels and associated civil works.

- Details of work requirements are covered in lighting installation notes and details and typical drawings which form the part of specification. Any changes, if necessary due to site conditions/requirements shall be carried out after obtaining approval of Purchaser/ Purchaser's Representative. The changes carried out shall be marked clearly in the layout drawings by Contractor and 'AS BUILT DRAWING' shall be prepared by the 'Contractor' and this shall be forwarded to Purchaser's site / design office.

a) Wiring

- i. Wiring shall be carried out strictly as per project drawings and technical specification. All exposed conduit wiring shall have provision for easy inspection. Where cable wiring is specified cable shall be cleated on to the wall as close to the ceiling as possible. In all types of wiring due consideration shall be given for neatness and appearance.
- ii. Wherever DC emergency lighting is provided, emergency lighting wires shall run in a separate conduit. Colour of the wires used shall be as follows; white for positive, black for negative.
- iii. Wherever lighting system has three phase distribution, separate conduits shall be used for different phases. For easy identification of phases and neutral wires the following colour wires shall be used.

R - Phase	-	Red
Y - Phase	-	Yellow
B - Phase	-	Blue
N - Neutral	-	Black

- b) There shall be a circuit breaker on each live conductor of supply mains at the point of entry.

- c) Conductors not arranged for connection to the same system or supply different phases of the same supply, shall be kept apart throughout their entire run.
- d) Receptacles and lighting fittings in general shall be fed from different Circuits. Five amps receptacles for toilet or small rooms can be fed from the lighting circuit with proper isolating arrangement.
- e) Each final sub-circuit from a lighting panel shall be controlled by a single pole switch connected to the live conductor.
- f) For long conduit wiring runs, inspection/ pull boxes shall be provided at intervals not exceeding 10 meter. Such facilities shall also be provided at conduit bends.

- General Practices

- a) All receptacles and switches to be installed in offices and control rooms shall be flush mounted within the wall and those in other areas shall be wall or column mounted.
- b) Ceiling roses shall not embody fuse terminals as an integral part. For voltages exceeding 250 volts, a ceiling rose or any similar attachment shall not be used.
- c) All exposed metal parts of the plug, when the plug is in complete engagement with the socket outlet, shall be in effective electrical connection with the earthing pin.

- Earthing

Conduits and fittings shall be earthed by 12 SWG GI wires run along the length of the conduit and secured by means of suitable clamps efficiently fastened to conduit tip. To achieve perfect electrical continuity, the conduits shall be bonded effectively on either end of a coupling and other joints.

- a) Conduits shall be earthed at the ends adjacent to switch boards at which they originate or otherwise at the earth clip, clamp or gland, in effective electrical contact with the conduit.

- b) For outdoor lighting poles & mast 8 SWG GI earth wire shall be run buried in ground at a depth of 600 mm along-with lighting cables and shall be terminated up to the junction box on the pole and 12 SWG wire shall be taken up to the pole fitting. In case of lighting poles where the main earth grid is far away from the pole, local pits shall be provided for pole earthing.

1.7 PRE COMMISSIONING TESTS ON ELECTRICAL SYSTEM EQUIPMENT TO BE CARRIED OUT AFTER INSTALLATION:

1.7.1 PRE-COMMISSION TESTS

Pre-commissioning tests in addition to mentioned in the specification requirements for various equipments but not limited to following shall be carried out by Contractor in presence of Purchaser/ Purchaser's representative. Commissioning shall be carried out only after obtaining satisfactory results, acceptable to Purchaser/ Purchaser's representative.

- HT Equipment (Lightning Arrestors, AB Switch/ Isolators & Insulators etc)
 - a) Visual checks for cracks in insulators.
 - b) Earth secured continuity check
 - c) IR Test with 5KV Megger
- Power / Distribution Transformer
 - a) Insulation resistance test HV side, LV side and HV - LV.
 - b) Magnetizing current test.
 - c) Winding resistance test.
 - d) Voltage Ratio & Tap continuity test at all tap.
 - e) Vector group test.
 - f) Magnetic Balance Test.
 - g) Buchholz Relay Test (if any)
 - h) Neutral CT Test (if any)

- i) Winding Temperature Indicator / Oil Temperature Indicator Test
- j) Polarization Index Test (For LV windings 3.3 KV and above)
- k) Local / Remote operations of OLTC (if any)
- l) Operational tests of RTCC panel (if any) as per schematic drawing.
- m) No load test and performance observations
- HT Metal Enclosed Switchgear
 - a) IR values of power and control circuits
 - b) Local/ Remote operations in test as well as service position including all electrical interlocks
 - c) Control circuit and operational tests as per schematic drawing.
 - d) Tripping through relays and trip circuit health.
 - e) Anti pumping device operation
 - f) Protection system operation stability and sensitivity by primary injection testing method including testing of metering circuits
 - g) HV Test on switchboard
 - h) Panel indication, annunciation, space heater circuits
 - i) Spare contact for customer use
 - j) Termination correctness & proper installation.
- LT Metal Enclosed Switchgears:
 - a) IR Values of power & control circuits.
 - b) Mechanical charging - closing - tripping of breaker.
 - c) Electrical charging - closing - tripping of breaker.
 - d) Trip circuit healthiness and tripping through relays.
 - e) Remote closing / Tripping / Interlocks circuits

- f) Indication / Annunciation / Panel space heater circuit / Spare contacts for customer use
- g) Secondary injection testing of protective relays/ releases.
- h) CT testing for polarity, ratio, IR values and magnetization for class PS characteristics
- i) PT testing for ratio, IR values.
- j) IR Values of breaker.
- k) Testing of modules for DOL/ Star-Delta/ ATS/ Soft Starter starting or any other starting method as per the schematic drawings applicable.
- Power and Control Cables:
 - a) IR Values before Hipot
 - b) Hipot Test - Measurement of leakage current
 - c) IR Values after Hipot
- Induction Motors:
 - a) IR Values
 - b) Polarization Index Test
 - c) Interlocks and simulation tests local / remote operations
 - d) No load test
- Control Panels For Miscellaneous Equipment:
 - a) IR Values of all power circuits
 - b) Operational test and scheme - wiring testing as per control schematics
- Lighting System:
 - a) Visual inspection for operating problems
 - b) System activation -burning in the lamps for 100 Hrs
 - c) Measuring light level & reflectance.

- Earthing System:
 - a) Earthing resistance of each electrode.
 - c. Earthing resistance of grid.

SECTION: IV
TECHNICAL SPECIFICATIONS FOR INSTRUMENTAION, CONTROL AND
AUTOMATION WORKS

SECTION: IV TECHNICAL SPECIFICATIONS FOR INSTRUMENTAION, CONTROL AND AUTOMATION WORKS

1.1 General

This specification covers the design, supply, engineering, manufacture, procurement, inspection & testing at vendor's and/or his sub-vendor's works, packing, transportation, delivery, storage & handling at site, erection, start-up, testing & commissioning and performance testing of all the Control, Instrumentation and Automation equipment/system with comprehensive Operation & Maintenance, as specified in the scope of work-Volume-II, for the plant along with required accessories and all essential spares, maintenance tools and tackles as specified hereafter. The offer shall comply with the latest applicable codes and standards as prevailing on the date of submission of the bids.

Adequate instrumentation, control & automation facilities shall be envisaged for the proposed Sewerage Treatment Plants (STP), with a view to achieve safe, reliable & trouble free operation of the plant equipment and safety of the operating personnel through user-friendly man-machine communication.

All the field-mounted transmitters shall be 'Smart' type. The instrumentation system shall be based on 4-20 mA DC signals, generally working on two-wire signal system with superimposed digital signal as per HART protocol. In addition to required measurements and controls, adequate sequential and safety interlocks, monitoring and display of all process parameters shall also be provided. All the signals/contacts between field & automation equipment shall be connected by suitable cables. The instrumentation & control equipment to be provided shall be suitable for continuous duty & for round-the-clock operation of the plant throughout the year.

Any equipment/accessories not explicitly indicated in this specification, but considered essential for proper functioning of process shall be included in Bidder's scope of work and supply.

1.2 Scope of Work:

Bidder's scope of work & supply shall include, but not limited to, the following:

Design, engineering, manufacture/ procurement, supply, delivery, transportation to site, storage, erection, testing and commissioning of all the field & control room mounted instrumentation & automation equipment.

Bidder shall execute complete Instrumentation & Control package on turnkey basis to the satisfaction of Purchaser/ Engineer. Bidder shall comply with all the requirements of scope of work and supply; list of measurements & controls, submission of drawings & documents; supply of instruments from list of approved makes and other related clauses, stipulated in this specification.

All field instruments (gauges/ sensors/transmitters/ switches/ flow meters/motorized valves etc.) as required for monitoring /control / alarm/ interlocking functions involved in the process.

All erection hardware and accessories like branch cable trays from field sensors to Junction boxes & from junction boxes to PLC cabinets, impulse tubes with fittings & accessories, drain/vent valves, root valves, cable glands, structural frames/supports, expander & reducer etc. as required for complete & proper installation of the instrumentation & control equipment, are included in bidder's scope of supply & work.

PLC based control system complete with cabinets, processor modules, I/O modules, power supply modules, communication modules & networks and other associated hardware. PLC based automation system shall be designed using adequate redundancy features. HMIs along with PLC panel & other peripherals shall be installed in the control room.

A separate control room with required facilities viz, air-conditioning, false ceiling, proper illumination, etc. is included in bidder's scope.

Supply of UPS of adequate capacity, with battery backup (SMF Ni-Cd batteries) of minimum one (1) hour. AC/DC power distribution from with adequate number of wired spares (minimum 20% after commissioning) breakers and 230V AC/ 24V DC converters (redundant) for I&C Equipment and System.

Supply, laying & termination of Instrumentation, Control, Power & any other special cables as required for entire system under Bidder's scope. Scope shall also include preparation of engineering documentation like cable schedule and Inter- connection schedule.

PC, consoles & other peripherals shall be of industrial grade & of latest available configurations.

Electronic earth pits, as per applicable standard & also meeting automation vendor's requirement and including supply & laying of earthing cables with required accessories shall be under Bidder's scope.

Bidder's scope shall also include supply of spares & consumables for successful commissioning and establishment of performance guarantee of the offered plant equipment & system.

Submission of drawings & documentation as specified in this bid document.

Provision of any other Instrumentation and control equipment, not specifically mentioned in this document, but required for trouble free and safe operation of the system, is also included under bidder's scope.

Bidder shall include & arrange for training of Purchaser's personnel for automation & special instrumentation items at manufacturer's works and also at site in his scope, details & modalities of which will be mutually discussed and finalised later.

Bidder's scope also includes arranging visits by respective instrumentation & automation equipment manufacturer's competent representatives at site, as & when required, during erection & commissioning.

It is not the intent to completely specify all details of design and construction herein. Nevertheless, the Instrumentation & Control system shall conform to high standard of engineering, design and workmanship in all respects and shall be capable of performing satisfactorily in continuous commercial operation under the specified environmental conditions.

Bidder shall include all necessary and supplementary items & equipment in his proposal, required for completeness, safe & efficient operation of the offered system, even though these may not have been mentioned in this specification.

Purchaser reserves the right to issue addendum to the technical specification to indicate modification/ changes in the requirements, if so required at a later date.

1.3 Design basis:

The monitoring and control system for the proposed plant shall be designed & implemented through a Programmable Logic Controller (PLC) based automation system, covering the total functional & operational requirements of the plant involving measurement, control, alarm & interlocking functions. All the process & electrical parameters shall be monitored in HMIs of the PLC system. PLC system selected shall be OPC compatible.

A Centralized Control Room (CCR) shall be provided for the STP, in which the automation equipment will be installed for automatic operation of the STP. PLC system shall be provided with hot redundancy features, one no. of Operator station (OS) & one no. of Engineering-cum-Operator station (ES-cum-OS) along with a printer, peripherals & accessories, as required. PLC based automation system shall be of latest industrially available configuration.

The PLC system shall be provided with hot redundant, fault-tolerant features, redundancy in processor, power supply modules, communication modules(I/O bus as well as HMI bus) and communication network, bump less switchover from the active system to the standby system in the event of a fault.

The PLC I/O modules shall be hot swappable, i.e. card changeover, card wiring removal or communication cable change shall be possible on-line (PLC running) without causing any process interruption, bump or nuisance trip or any loss of fidelity during such action. In case of hot swap of I/O card or card wiring removal, the interruption shall be limited to the subject card related I/Os only. On line PLC programme modification shall be possible without stopping the processor.

All analog cards shall be differential type. The cards and processors shall be of same family and series. I/O modules shall have 3 levels of Isolation- a) Channel to Channel Isolation, b) Channel to power Isolation & c) Channel to Ground Isolation.

Channel level diagnostic features shall be available in HMI. The engineering station forms the focal point of the control system design and acts as container of the complete control system application.

The operation & status monitoring of the motorized valves shall be performed from the PLC.

Local instruments like pressure gauges, pressure switches, temperature gauges, level gauges, level switches etc. shall be provided as per the process requirement for proper functioning of the plant.

All the instrumentation & automation equipment and their accessories shall be supplied from approved manufacturers (list is provided in **Volume II-C**), whose successful performance has been established by record of satisfactory operation in process plants.

Separate electronic earthing system with dedicated earth pit shall be provided by the bidder for ICA equipment. Bidder shall also be responsible for the laying of the network of electronic earthing cables including all the applicable accessories.

Bidder shall be responsible for engineering, selection and connection of all components and sub systems to form a fully complete system whose performance is in accordance with functional, parametric and other requirements of this specification. It is not the intent to specify all individual system components since the bidder has full responsibility for engineering and furnishing of a complete system meeting the monitoring and control requirements of all equipment associated with the system.

Bidder shall support for spares & services for PLC including HMI software and operating System for at least next fifteen (15) years from the date of commissioning.

The tagging, numbering & colour philosophy shall be as per as per ISA standard.

Instrumentation, Control & Automation (ICA) system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation in STP. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

All ICA equipment shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalised. The outdoor equipment shall be designed to withstand tropical rain. Wherever necessary, space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.

Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 70% of the full scale range.

Unless otherwise stated, degree of protection for field mounted electrical and electronic instruments shall be IP 65. All instruments of submersible type shall be protected to IP 68.

Unless otherwise stated, overall accuracy of all measurement systems shall be $\pm 1\%$ or better of the measured value.

Dual redundant SMPS shall be used for powering 24 V DC Instrumentation, Control & Automation equipments.

For all the field mounted transmitters, output signal shall be 4-20 mA DC isolated with HART Protocol (version 6 & above) and field transmitters shall be provided with the back lit LCD/LED display.

Lockable & tamperproof enclosure shall be provided for all the field mounted instruments.

FRP Canopy shall be provided for all the field instruments to protect the instruments from rain, sunlight and weather conditions.

1.4 List of Measurements and Control:

The plant shall be provided with required instrumentation equipment for measurement & control functions, indicated below as a minimum, but not limited to the following:

- a) Flow measurement at inlet and outlet of STP
- b) Flow measurement at common header of pumps
- c) Pressure and flow measurement in process air pipeline
- d) Pressure measurement at discharge of each pump/ blowers & common header
- e) Level measurement of each sump & tank
- f) Differential Level measurement across the screen
- g) Dissolved oxygen measurement at Aeration tank/ Biological reactor
- h) Total suspended solids(TSS) , BOD & COD at inlet & outlet of STP

- i) Residual chlorine at outlet of CCT
- j) Control of Pumps based on plant conditions
- k) Monitoring and control of electrical systems such as Energy Meter readings, Breaker control, etc.

Notes-

- a) Bidder may propose additional instruments & control equipments for safe, reliable & efficient operation of STP process proposed by him.
- b) Required quantities and application of the above instruments shall be provided as per approved P&ID to meet the requirement of the process.
- c) Necessary alarms, status signals along with the measurements of process parameters etc. shall be displayed in HMI.

1.5 Reference Specifications and Standards

All ICA equipment shall comply with all applicable international and local laws regulations and standards, as mentioned in the bid document.

1.6 Submission of Drawings & Documents:

To be submitted along with the Bid (as minimum, but not limited to following):

As per the list given in Volume-IIA, Part-3

To be submitted after the award of Contract (as minimum, but not limited to following):

As per the list given in Volume-IIA, Part-3

1.7 General Design Requirements

Instrumentation, control & automation (ICA) system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation in STP. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

Electronic instruments shall utilize solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.

All digital outputs from the instruments shall be volt free. The relay/switch contacts shall be rated for the voltage of the circuit in which they are to be wired.

All analogue displays shall be of the digital type with no moving parts..

Zero and span adjustments shall be provided for all instruments.

After a power failure, when power supply resumes, the instruments and associated equipment shall start working automatically.

The instruments shall be designed to permit maximum inter-changeability of parts and ease of access during inspection and maintenance.

The field instruments i.e. the instruments mounted outside the control panel shall be mounted at a convenient height of approximately 1.2 meters above grade platform.

All the field mounted transmitters shall be provided with back lit display.

The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail. The instruments shall be given enough protection against corrosion and all the wetted parts of the instruments shall be non-corrosive.

All field instruments and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them.

The performance of all instruments shall be unaffected for the $\pm 10\%$ variation in supply voltage and $\pm 5\%$ variation in frequency simultaneously.

Unless otherwise specified, SS 304 double compression glands with PVC shroud shall be used for glanding the cable in field instruments and instrument control panel.

1.8 Fields Instrumentation

1.8.1 Ultrasonic / Radar / Hydrostatic Level Measuring System

Ultrasonic / Radar / Hydrostatic level measuring system shall consist of a level sensor, level transmitter cum computing unit, prefabricated cable connecting the sensor and transmitter, panel mounted digital level indicator and any other item required for completing the level measurement system.

The level sensor shall be suitable for flange or bracket mounting as required and have a minimum protection conforming to IP 65. It shall have ambient temperature compensation and adjustable datum setting facilities.

The level transmitter cum computing unit shall be provided in an enclosure conforming to IP 67. It shall be programmable with an integral programming keyboard, LCD display, relays for alarm, control and system fault.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.

Technical Particulars

a)	General		
i.	Service	:	Level measurement as per P&ID
ii.	Overall accuracy of measurement loop	:	± 0.5% of full scale
iii.	Range	:	As per reservoir/sump dimension. (To be finalised during detailed engineering without any cost implication)
b)	Level sensor		
i.	Type	:	Ultrasonic / Hydrostatic / Radar
ii.	Weather protection class	:	IP 65
iii.	Process connection	:	As per process requirement
iv.	Temperature compensation	:	Required
v.	Swirling arm arrangement for mounting of sensor	:	Required for access during maintenance
c)	Level transmitter		
i.	Type	:	Microprocessor based SMART type with backlit LCD / LED display

ii.	Programming facility with programmer	:	Required
iii.	Output	:	<ul style="list-style-type: none"> 4-20 mA DC isolated with HART protocol (version 6 or above) proportional to level Relay output for loss of echo alarm (only for level application) and high and low alarms(Configurable)
iv.	On line diagnostic facility	:	Required
v.	Facility to suppress the echo from interfering structures	:	Required
vi.	Facility for averaging / dampening the readings due to water turbulence	:	Required
vii.	Enclosure material	:	Die cast aluminium with epoxy coating
viii.	Enclosure protection class	:	IP 65
ix.	Mounting	:	Wall / panel
d)	Digital Level indicator		
i.	Type	:	Microprocessor based
ii.	Display	:	Digital LED display
iii.	Digit Height	:	14 mm or higher
iv.	No. of Digits	:	3 ½
v.	Input	:	4-20 mA DC with HART protocol (version 6 or above) -2 nos.
vi.	Zero & Span Adjustment	:	Required
vii.	Engineering Units for display	:	Meters and %.
viii.	Accuracy	:	±0.1 % of span
ix.	Enclosure Material	:	Non corrosive
x.	Retransmission output	:	Isolated 4-20 mA DC-2nos.
xi.	Power supply to Transmitter	:	24 V DC
xii.	Alarm outputs	:	1NO+1NC for high, low and Low-Low

			alarms (adjustable)
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1.8.2 Capacitance type Level Measuring System

Capacitance type level meter shall consist of level probe, stilling pipe & transmitter which will be mounted on the reservoirs and panel mounted digital level indicator and connecting cable.

To reduce the effect of water turbulence in the reservoir, averaging facility shall be provided in the transmitter unit for providing steady readings.

The design and application of the level measuring system shall take into account the reservoir construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

Probe head and all electronic enclosure shall be weather proof to IP65.

Material selection shall be selected to withstand the process without compromising on instrument performance.

Technical Particulars

a)	General		
(i)	Service	:	Sumps/Tanks as per P&ID
(ii)	Overall accuracy of measurement loop	:	± 1.5% of full scale
(v)	Range	:	As per reservoir/sump dimensions
b)	Level sensor		
(i)	Type	:	Capacitance
(ii)	Weather protection class	:	IP 65
(iii)	Process Connection	:	Flanged
(iv)	Temperature compensation	:	Required
(v)	Probe Type Material Length Accessory	: : : : :	Rod (wire rope with counter weight for lengths longer than 4 meters) SS 316 with Teflon coating As per reservoir dimensions SS 316 stilling pipe which will work as ground electrode.

c)	Level transmitter		
(i)	Type	:	Microprocessor based SMART type with backlit LCD / LED display
(ii)	Local display		Indicating type with LCD/LED display
(iii)	Programming facility	:	Required
(iv)	Power Supply	:	24 V DC
(v)	Output	:	<ul style="list-style-type: none"> 4-20 mA DC, with HART protocol (version 6 or above) -2 nos. High and low level alarm
(vi)	Diagnostic facility	:	Required
(vii)	Weather protection class	:	IP 65
d)	Digital Level Indicator		
(i)	Type	:	Microprocessor based
(ii)	Display	:	Digital LED display
(iii)	Digit Height	:	14 mm or higher
(iv)	No. of Digits	:	3 ½
(v)	Input	:	4-20 mA DC with HART protocol (version 6 or above) -2 nos
(iv)	Zero & Span Adjustment	:	Required
(iiv)	Engineering Units for display	:	Meters
(iiiv)	Accuracy	:	±0.1 % of span
(ix)	Enclosure Material	:	Non corrosive (Aluminium with Powder coating)
(xi)	Retransmission output	:	Isolated 4-20 mA DC-2 nos
(xii)	Power supply to Transmitter	:	24 V DC
(xii)	Alarm outputs	:	1NO+1NC for high, low and Low-Low alarms (adjustable)

1.8.3 Level Switch

Conductivity type level switch shall be provided on the reservoir as per approved P&ID for generating control outputs and alarms.

The conductivity type level switch shall consist of level probes mounted on the reservoir, connected by suitable cable to the conductivity controller unit for generating control actions and high / low level alarms.

The controller output shall be connected to the instrument control panel for generating an alarm when the water level becomes Low or High and pump tripping signal when the level becomes very low.

The conductivity type level switch shall work on the principle of detecting presence or absence of liquid between two electrodes based on conductivity. The voltage at electrodes shall be A.C. The controller unit shall be electronic using ICs or microprocessors. Both the electrode assembly and the controller unit shall be suitable for field installation.

The Contractor shall provide extra lengths of electrodes and adjust the length by cutting the excess lengths at site, as necessary.

The level probes shall be installed on a flanged connection on the reservoir. The Contractor shall provide the required nozzle and the matching flanges.

Stilling pipe shall be provided for level electrodes in order to obviate the effect of water turbulence in the reservoir.

The conductivity type level switch shall function for normal conductivity of water.

Technical Particulars

a) General			
i.	Service	:	As per P&ID
b) Level probe			
i.	Type	:	Rod / Rope type
ii.	Weather protection class	:	IP 65
iii.	Probe material	:	SS 316
iv.	Probe head material	:	Non corrosive
v.	Insulation on the probe	:	Teflon

vi.	Counter weight for rope type probe to keep it straight		Required
vii.	Spacers between the probes to avoid entangling with each other	:	Required
viii.	No. of electrodes	:	4 nos. (high, Low, Very low and reference)
ix.	Length of the electrodes	:	Suitable for reservoir dimensions
x.	Stilling pipe	:	Perforated HDPE pipe Internal diameter to suit the level probe assembly
c) Level Controller Unit			
i.	Mounting	:	Inside local cabinet fabricated from sheet metal.
ii.	Weather protection class	:	IP 65
iii.	Alarm contacts	:	For high, Low and Lo-Lo.
iv.	Contact rating	:	24 VDC 2 A / 230VAC 1 A.
v.	Power supply	:	230 VAC
vi.	Material of enclosure	:	Non corrosive
vii.	Sensitivity adjustment for conductivity	:	Required

1.8.4 Full bore Electromagnetic flow meter:

Full bore type Electromagnetic flow meter shall be provided as per approved P&IDs. The flow meter shall consist of flow sensor (i.e. flow tube), flow transmitter/ flow computing unit and remote flow indicator cum integrator. The electromagnetic flow meter shall be manufactured as per BS EN ISO 6817 standard (Measurement of conductive liquid flow in closed conduits, method using electromagnetic flow meters).

The flow tube flanges and transmitter housing shall be properly earthed.

Flow tube shall have waterproof construction (IP 68) and shall be suitable for installation on underground pipe lines buried directly in the soil and also suitable for above ground pipelines.

The transmitter of the flow meter shall be SMART type microprocessor based using digital technology having facilities for configuration of engineering units, flow range and features of memory and self diagnosis. The transmitter shall be mounted separate from the flow tube, connected by a cable. The flow transmitter and flow computation/ evaluation unit shall be mounted in a field mounted metallic field enclosure / cabinet.

The electromagnetic flow meter shall have bi-directional measurement feature and with accuracy better or equal to $\pm 0.5\%$ of measured value inclusive of linearity, repeatability, pressure effect etc.

Flow transmitter/ flow computing unit should be microprocessor based having digital display with flow-rate indications and integrated flow values with the configuration facility from the front facia.

Material of construction of the wetted parts of flow meters shall be suitable for functioning on treated / raw and chlorinated water applications. Flow tube shall be rugged in construction and shall be suitable for continuous operation. Flow meters shall be suitable for the water turbidity at site during various seasons.

The flow meter shall be installed in such a way that it always remains filled with water. To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided, as required by the flow meter manufacturer. The flow tube shall be installed at a location free from flow turbulence. In order to achieve the same, the flow tubes shall be installed in the pipe section such that straight lengths of pipe without bends or tee connection shall be minimum 5 diameters on upstream and 3 diameters on downstream side. The Contractor shall finalize the exact location of flow transducers in consultation with Employer.

The flow meter output signals shall contain the data for flow-rate and integrated flow readings. The output signal of the flow meter will be connected to panel mounted Flow Indicator & integrator and PLC.

1.8.5 Technical Particulars

a)	General		
i.	Service	:	As per P&ID
ii.	Overall accuracy of measurement loop	:	$\pm 0.5\%$ of reading
iii.	Quantity	:	As per P&ID

iv.	Internal diameter of pipe	:	As per P&ID
v.	Suitable concrete chamber for enclosing flow meter.	:	Required
b)	Flow tube		
i.	Type	:	In line full bore electromagnetic
ii.	Size of flow tube	:	Same as pipe size
iii.	Weather Protection Class	:	IP 68
iv.	Range	:	Bidder to state
v.	Surge protection devices (SPD) between flow tube and flow transmitter	:	Required for protection from lightning surges
vi.	Electrode material	:	Hastelloy C
vii.	Flow tube Lining	:	Polyuethane / PTFE
c)	Flow Transmitter Unit		
i.	Type	:	SMART type Microprocessor based with facility to configure the ranges.
ii.	Type of display	:	4 digit, LCD for flow rate in m ³ /hr. 8 digit LCD for totalised flow in ML
iii.	Input	:	From flow tube
iv.	Output	:	4-20 mA DC (isolated) with HART protocol (version 6 or above) proportional to flow rate -2 nos.
v.	Power Supply	:	230V AC / 24V DC
vi.	Zero and Span Adjustment	:	Required
vii.	Weather Protection Class	:	IP 67
viii.	Battery backup for totalised flow	:	Required
ix.	Facility for on line diagnosis	:	Required
d)	Flow Indicator and Integrator		
i.	Type	:	Electronic, Microprocessor based, single unit for flow indicator and

			integrator.
ii.	Display	:	Digital, LED display
iii.	Digit Height	:	14 mm or Higher
iv.	No. of Digits - Flow indicator - Flow integrator	: : :	4 Digits 8 Digits
v.	Input	:	4-20 mA DC (Isolated) with HART protocol (version 6 or above) from flow transmitter for flow rate
vi.	Zero and span adjustment	:	Required
vii.	Manual Reset Facility for flow integrator	:	Required (shall be protected)
viii.	Engineering Units for - Flow rate indicator	:	CUM / Hr
ix.	Battery backup for flow integrator	:	Required
x.	Retransmitted output	:	Required

1.8.6 Pressure Gauges:

Pressure gauges shall comply with IS 3624. Where the gauge is subject to pressure pulsations and/or vibration, it shall be mounted on gauge board / stanchion.

The minimum diameter for round pressure gauges shall be 150 mm unless specified otherwise or as per the equipment manufacturer's standard practice when the gauge forms part of the equipment.

Technical Particulars:

i.	Service	:	As per P&ID
ii.	Range	:	As per pump design (Range to be finalised during detailed engineering without any cost implication)
iii.	Accuracy	:	±1% of full scale or better
iv.	Dial size	:	150 mm
v.	Glass	:	Shatterproof
vi.	Over range protection	:	125% of maximum pressure

vii.	Housing material	:	Die cast aluminium with epoxy coating
viii.	Material of sensor and other wetted parts	:	SS 316
ix.	Blow out disc	:	Required
x.	Process connection	:	As per process requirement
xi.	Material of dial	:	Aluminium with white back ground and black numerals
xii.	Accessories		<ul style="list-style-type: none"> • Diaphragm seal assembly with SS 316 diaphragm (as applicable) • 3 way isolation valve • Impulse tubing, fittings • Snubber • All other installation hardware

1.8.7 Pressure Measuring System

Pressure measuring system shall consist of a pressure sensor/transducer/transmitter and panel mounted digital pressure indicator and any other items required for completing the measuring system. Where the transmitter is subject to pressure pulsations and/or vibration, it shall be provided with snubber.

The pressure transmitters shall be designed for operation over 130 % of full range.

Technical Particulars

i.	Service	:	On common discharge header of pumps/blowers and as indicated in P&ID.
ii.	Accuracy of measuring loop	:	± 0.1% of reading or better
iii.	Type	:	Capacitive/piezoelectric / Silicon resonance

iv.	Material of sensor and other wetted parts	:	SS 316
v.	Transmitter type	:	SMART type, 2-wire indicating type with LCD display for pressure MWC or kg/cm ²
vi.	Range	:	Range to be finalised during detailed engineering without any cost implication
vii.	Zero and span adjustment	:	Required
viii.	Output signal	:	4-20mA DC isolated with HART protocol (version 6 or above) proportional to pressure-2nos.
ix.	Enclosure material	:	Die cast aluminium / non-corrosive
x.	Enclosure protection class	:	IP 65
xi.	Ports for in situ calibration	:	Required
xii.	Over range protection	:	130 % of full range
xiii.	Process connection	:	As per process requirement
xiv.	Accessories	:	<ul style="list-style-type: none"> • Diaphragm seal assembly with SS 316 diaphragm(as applicable) • 3 way isolation valve • Impulse tubing, fittings • Snubber • All other installation hardware

1.7.6.1. Digital Pressure Indicator

Refer specifications of digital panel meter in this section.

1.8.8 Pressure Switches

Technical Particulars

i.	Service	:	As per P&ID
ii.	Accuracy	:	+ /- 1% of full scale or better
iii.	Range	:	As per pump design, Adjustable setting over full span and as per P&ID.
iv.	Overrange Protection	:	125% of range
v.	Body Material of casing	:	Die Cast Aluminium / non-corrosive
vi.	Material of sensor and other wetted parts	:	SS 316
vii.	Set point adjusting scale	:	Required
viii.	Accessories	:	2 valve manifold with drain cock, Impulse tubing, fittings, Snubber and all other installation hardware

1.8.9 Digital Panel Meter

Digital Panel Meters (DPM) shall be microprocessor based and modular in design. They shall accept 4-20 mA DC signals from transmitters. The DPM's shall provide an output of 4-20 mA DC proportional to input signal for re-transmission. The DPM'S shall have LED display.

Technical Particulars

i.	Type	:	Microprocessor based
ii.	Display	:	Digital seven segment LED display
iii.	Digit height	:	12.5 mm or higher
iv.	No. of digits	:	4 digits
v.	Input	:	4-20 mA DC (isolated) with HART (version 6 or above)
vi.	Zero & span adjustment	:	Required
vii.	Engineering units for display	:	<ul style="list-style-type: none"> For level - metre For pressure – MWC or

			kg/cm ²
viii.	Accuracy	:	±0.1 % of span
ix.	Enclosure material	:	Die cast aluminum / non-corrosive
x.	Enclosure protection class	:	IP 52
xi.	Retransmission output	:	4-20 mA
xii.	Alarm outputs	:	2 NO+ 2NC for high and low alarms (adjustable). Contact rating 5A, 230 VAC.
xiii.	Power supply to transmitter	:	Required

1.9 Analytical Instrumentation & Measurement

1.9.1 DO Measurement/Analyzer:

1.9.1.1 General

The sensor should be unaffected by pH swings, hydrogen sulfide, wastewater chemicals, heavy metals, or organic build-up on the sensor. Warm-up time is not required so the analyzer can start measuring within 30 seconds of switching on.

The dissolved oxygen probe shall be a continuous-reading probe that utilizes luminescent sensor technology.

The probe material shall be foamed Noryl® and 316stainless steel. All parts of the probe shall be corrosion resistant and fully-immersible. The sensor material shall be polybutyl methoacrolate. The operation of the analyzer shall not be affected by H₂S, pH, K⁺, Na⁺, Mg⁺, Ca⁺, NH₄⁺, Al⁺, Pb⁺, Cd⁺, Zn⁺, Cr (total), Fe⁺, Fe⁺, Mn⁺, Cu⁺, Ni⁺, Co⁺, CN⁻, NO₃⁻, SO₄⁻, S⁻, PO₄⁺, Cl⁻, anion active tensides, crude oils, or Cl₂ -1. -1.

The probe shall provide electrolyte-free operation without the requirements of sample conditioning. The probe shall be furnished with choice of pole or ballfloat mount kit. The sensor cap shall be warranted for one full year against defects in material and workmanship. The probe shall be warranted for three full years against defects in material and workmanship. The analyzer sensor shall be Luminescence dissolved Oxygen (LDO) type.

The Probe / Sensor should be of detachable type and should be supplied along with dual input controller like SC1000 or SC200 digital controllers

1.9.1.2 Technical Particular

	General		
i.	Service	:	Measurement of Dissolved Oxygen in the Aeration Tank.
ii.	Repeatability	:	± 0.5% of span
iii.	Range		0 – 20 mg/L(ppm)
	Accuracy	:	Below 1 ppm: ±0.1 ppm , Above 1 ppm: ±0.2 ppm
	Response time at 20oC	:	To 90% in less than 40 seconds , To 95% in less than 60 seconds
	Operating Temperature	:	0 to 50°C (32 to 122°F)
	Sensor		
i.	Type	:	Immersion Type
ii.	Mounting	:	In Aerobic Tank
iii.	Installation hardware and Integral cable	:	Required
iv.	Probe Material	:	Suitable for sewage application
v.	Sensor Cable (integral)	:	10 m (33 ft.) terminated with quick-disconnect plug
vi.	Wetted Materials	:	Probe: Foamed Noryl® and 316 stainless steel
vii.	Sensor	:	Suitable for Sewage application
	Transmitter		
i.	Type	:	Microprocessor Based having back Lit LCD display
ii.	Mounting	:	Field
iii.	Prefabricated integral cable for connecting sensor and transmitter	:	Required
iv.	Analog outputs	:	4-20 mA
v.		:	

1.9.2 Residual Chlorine Measurement/Analyzer
1.9.2.1 General

Service	:	Measurement of residual chlorine
Cycle time	:	One complete sample analysis every 2-1/2 minutes
Range	:	0 to 5mg/L free or total residual Chlorine, with automatic color/turbidity compensation
Accuracy	:	±5% or 0.035 mg/L as Cl ₂ , whichever is greater
Precision	:	±5% or 0.005 mg/L as Cl ₂ , whichever is greater
Minimum Detection Limit	:	0.035 mg/L

1.9.2.2 Sensor

Type	:	Colorimetric Type
Mounting	:	Off line
Installation hardware and	:	Required
Integral cable		
Probe material		Suitable for Sewage application

1.9.2.3 Transmitter

Type	:	Microprocessor Based having back Lit LCD display
Mounting	:	Field
Prefabricated integral cable for connecting sensor and transmitter	:	Required
Power	:	100-115/230 VAC, 50/60 Hz (switch selectable), 90 VA maximum\
Enclosure	:	ABS plastic, IP65 enclosure rating with two clear polycarbonate windows

Analog outputs

One 4-20 mA with an output span programmable over the 0 to 5 mg/L range.

Note: Bidder has to supply, any other Analytical Instrument required as per P&ID or Process requirements without extra cost to Employer.

1.9.3 Laboratory Instruments:

The STP shall be provided an administrative building that will house the laboratory. The laboratory shall be equipped with instruments, equipment, chemicals and other infrastructure that is necessary to perform the routine analysis for the parameters as detailed in table below.

STP Contractor shall submit the complete list of lab equipments required for full analysis of parameters to the employer's representative for approval. Contractor shall include in his offer supply of chemicals required for analysis along with proposed lab instruments and associated equipment, including for the O&M period as specified elsewhere in the bid document.

Typical Laboratory equipments to be provided are detailed as below:

Item	Description	Unit	Quantity
1	Comparator test set for residual chlorine or chloroscope	No.	1
2	Multi parameter (pH & Conductivity Meter)	No.	1
3	Mains operated pH meter completed with one calomel electrode and glass electrode	No.	1
4	Photoelectric calorimeter / Spectrophotometer	No.	1
5	Water bath with 6 to 8 concentric holes and discs, electrically heated	No.	1
6	Hot plates	No.	25
7	Distilled water plant	No.	1
8	Demineraliser	No.	1
9	Refrigerator (280 litres capacity) double door	No.	1
10	Muffle furnace	No.	1
11	Electric oven	No.	1
12	Magnetic stirrer	No.	1
13	Analytical balance with weight box	No.	1
14	Jar-Test apparatus (Phipps & Bird)	No.	1
15	Centrifuge	No.	1
16	Gas cylinder if gas supply is not available	No.	1
17	Fume cupboard	No.	2
18	Depth Sampler	No.	2
19	Total Organic Analyser	No.	1
20	Sieve shaker with standard sieves and two pan balance weighing up to 200gm samples	No.	1
	Equipment Needed For Bacteriological Examination		
21	Hot Air Oven	No.	1
22	Autoclave	No.	1
23	Incubator 37°C or 44°C (Water/Air-Jacketed)	No.	1
24	Binocular microscope	No.	1
25	pH Meter	No.	1
26	Pipette Box (Stainless Steel)	No.	10

Item	Description	Unit	Quantity
27	Wooden Racks/Aluminum Racks	No.	5
28	Wire Baskets	No.	10
29	Cotton/ Aluminum Foils	No.	10
30	Burners (Bunsen) With Pilot Lamp	No.	3
31	Suction Flask (1 Litre Cap)	No.	2
32	Suction Pump	No.	1
33	Sampling Bottles	No.	10
34	Measuring Cylinders (1000 MI, 500 MI, 200 MI, 100 MI, 50 MI, 25 MI)	Set	3
35	Vacuum pump	No.	1
36	Soxhlet extraction unit	No.	1
37	Kjeldhal digestion unit	No.	1
38	Weighing Balance (max 10kg)	No.	1
39	Laminar Air Flow chamber	No.	1
	Bacteriological Media		
40	M. Endo Broth (dehydrated)	No.	1
41	Lactose or Lauryl Tryptose broth	No.	1
42	Mac Conkey broth	No.	1
43	Brilliant Green Bile Lactose Broth	No.	1
44	Total Plate Count Agar	No.	1
45	Peptone/Tryptone Water	No.	1

The equipment shall be supplied with all the accessories that are necessary to make the equipment functional for analyzing parameters. Contractor shall provide additional Equipment if necessary for the performance of the plant without extra cost to the Employer.

1.9.4 Work Tables and Benches

Minimum of 1set of work table and chair per staff shall be provided for the laboratory and office staff. The furniture and chairs shall be of ergonomic design.

The work tables shall be along the wall and shall be provided with adequate storage capacity and open glass shelves on the top to provide additional space for storage of chemicals and stock solutions.

A fume cupboard with ventilation hood shall be provided to prevent spreading of toxic and irritant fumes and odours into other parts of the laboratory. Forced ventilation

with exhaust fans shall be provided. The wall space and offsets shall be convenient to locate cabinet, benches, hoods, incubators alongside without any loss of floor space.

1.9.5 Control Panel

A control panel shall be provided at sewage treatment plant for the operation and monitoring of the pumps, MOVs, equipments etc. The panel shall be fabricated from cold rolled sheet steel of 2 mm thickness with powder coating and shall be suitable for wall mounting or pedestal mounting as required. The gland plate thickness shall be 3mm. The paint shade shall be RAL 7035.

The panel shall conform to IP 52 weather protection for non AC indoor area, IP 20 for AC indoor area and IP 55 for outdoor area and shall have built in locking facility. The panel shall be properly earthed. The panel shall have bottom cable opening.

Voltage level for control schemes and power supply for instruments in the panels, shall be limited to 230 VAC. Any other necessary voltage shall be derived by the Contractor using necessary inverters, converters, transformers, rectifiers etc. which shall be in his scope of supply.

Strip type space heaters of adequate capacity shall be provided inside control panels to prevent moisture condensation on the wiring and panel mounted equipment when the panel is not in operation. The heaters shall operate on 230 VAC. Heaters inside the panels shall not be mounted close to the wiring or any panel mounted equipment. The operation of heaters shall be controlled by thermostats.

The panel shall be provided with either a fluorescent lighting fixture rated for 230 VAC supply for the interior illumination of the panel during maintenance. The illumination lamp shall be operated by door switch. Additionally, the panel shall be provided with 230 VAC combined 5 amps and 15 amps, 3 pin receptacle with a switch and neon indicating. The receptacle with switch shall be mounted inside the panel at a convenient location.

All the equipment mounted on the front facia of control panel as well as equipment mounted inside the panels shall be provided with individual labels with equipment designation engraved. The labels shall be mounted directly below the respective equipment. Also the panel shall be provided at the top with a label engraved with panel designation.

Each control panel shall be provided with necessary arrangement for receiving, distributing, isolating and protecting of DC and AC supplies for various control,

signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Miniature Circuit Breakers (MCBs). Potential circuits for relaying and metering also shall be protected by MCBs.

Connections within a panel, between panel mounted devices and terminal blocks or between two panel mounted devices shall be made PVC insulated stranded copper conductor. The wires shall be shielded for all analogue signals.

Panels shall be supplied completely wired internally, with a colour coding scheme to be finalised during detailed engineering, to equipment and terminal blocks and ready for external cable connections at the terminal blocks.

Wires within the panel shall be continuous i.e. without splicing and shall comprise stranded copper conductors.

Wire termination shall be made with solderless crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules, marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit of breaker or device shall be distinguished by the addition of a red coloured unlettered ferrule.

Terminal blocks shall be one-piece moulded, complete with stud type terminals, washers, nuts and lock nuts and identification markings. Terminal block design shall include a white fiber marking strip with clear plastic, hinged terminal covers. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams.

All spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks.

There shall be a minimum clearance of 250 mm between the first row of terminal blocks and the associated cable gland plate. Also the clearance between two rows of terminal blocks shall be a minimum 250 mm.

Panel internal wiring shall not be looped directly from instrument to instrument. The same shall be looped through the panel terminal block only.

If accidental short circuiting of certain wires is likely to result in malfunction of equipment, such as closing or tripping of a breaker or positive and negative wires, these wires shall not be terminated on adjacent terminal blocks.

Cabinets for Field Instruments

- A cabinet shall be provided for enclosing instruments and associated accessories which are mounted outside the control panel such as transmitters, SPDs, terminal blocks etc. at all measurement locations. The cabinets for electronic indicating instruments like transmitters, flow computing units etc. mounted outdoors shall be provided with proper sunshade.
- The cabinets shall be fabricated from cold rolled sheet steel of 2 mm thickness with powder coating and shall be suitable for wall mounting or pedestal mounting as required.
- The cabinet shall be properly painted from inside and from outside by paint shade RAL 7035.
- The cabinet shall conform to IP 65 weather protection and shall have built in locking facility. The cabinet shall be earthed properly. A steel plate/pipe, as per the requirement, shall be provided in the cabinet for mounting the instrument and accessories.

1.9.6 Cables and Cabling

Instrumentation Signal Cables:

1100V grade, Multi pair 7 stranded x 0.53mm dia, Stranded tinned Electrolytic copper conductor of insulation HRPVC Type-C, Pairs shall be twisted with a lay of 50 mm and twisted to each other, Lapped to form bunch with Mylar tape. Individual as well as overall Shielded with Polyethylene coated Aluminum Mylar tape (min shield thickness .05 mm for single pair & 0.075mm for multi pair) with tinned Copper drain wire. Internal & External sheath of Extruded FRLS PVC, Thickness as per International Standard, Suitable for temperature up to 70 deg. Celsius. G.I. wire/strip armouring of international standard thickness. Max. DC resistance shall not exceed 12.3 ohms/km at 20 deg. Celsius. Applicable standard shall be IS 1554 / BS 5308 / IEC 189.

RTD cables:

1100V grade, triad cables 7 stranded x 0.53mm dia, stranded tinned Electrolytic copper conductor. Three insulated conductor shall be uniformly twisted with a min. 20 twist per meter. Individual as well as overall Shielded with Polyethylene coated Aluminum Mylar tape (min shield thickness .05 mm for single pair & .075mm for multipair) with tinned Copper drain wire. Internal & External sheath of Extruded FRLS PVC, Thickness as per International Standard, and Suitable for temperature up to 70

deg. Celsius. G.I. wire/strip armouring of international standard thickness. Max. DC resistance shall not exceed 12.3 ohms/km at 20 deg. Celsius.

Ethernet Cables:

EIA/ TIA 568A category 6, multi pair 0.5 sq. mm solid conductor with plastic foil wrapping. Overall screen to consist of aluminium bonded polyester tape and tinned copper wire. Overall sheath shall be light grey PVC.

Fiber Optic Cables:

9/125 micron single mode graded index, glass silica fiber core, mechanical protection provided by round galvanized steel armour with polyester laminated tape layered over inner sheath. Outer sheath shall be orange. HDPE conduit shall be orange.

Power Cables for Instrumentation, Control & Automation equipment:

Power cables for ICA equipment shall be 2.5 sq.mm, 1100V multicore cables using high conductivity annealed tinned stranded copper conductor having extruded PVC insulation. The cables shall be inner sheathed with extruded PVC. Armouring shall be with galvanised steel wire and overall sheath shall be extruded PVC. Applicable standard shall be IS 1554 / BS 5308 / IEC 189.

Control cables:

Refer electrical specification for Control cables.

Laying of Cables

- a) A distance of minimum 300mm shall be maintained between the cables to be laid on trays/conduits carrying low voltage AC and DC signals and a distance of minimum 600mm shall be maintained between cables carrying HT and LT signals. Each instrumentation and power supply cable shall be terminated to individual panel/ terminal box. Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by Contractor.
- b) Cables shall be laid in accordance with layout drawings and cable schedule which shall be prepared by Contractor and submitted for approval.
- c) All cable routes shall be carefully measured and cables cut to the required lengths, leaving sufficient amount for the final connection of the cable to the

terminals on either end. Various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables. A loop of 1 metre shall be left near each field instrument before terminating the cable.

- d) Cables shall be complete uncut lengths from one termination to the other. Separate cables shall be used for digital and analog signals.
- e) All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedules. Identification tags shall be securely fastened to the cables at both the ends.
- f) Cable shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports or cable trays.
- g) The Contractor shall take the actual measurement of the cables and the associated accessories such as cable trays, conduits etc required at site, prior to the placement of order on the cables.

1.9.7 Junction Boxes

- In order to make the most economic use of cable tray and trench capacity, multicore / multipair cabling shall be utilised in order to connect instrumentation groups by using suitably located junction boxes.
- The junction boxes shall have weather protection suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labelled. Junction boxes shall be constructed of die cast aluminium and provide degree of protection IP 65.
- Wires and terminals for the digital and analog signals shall be segregated within junction boxes.

1.10 Instrument control panel with PLC based SCADA (Supervisory Control & Data Acquisition) system

- A PLC control room shall be provided for monitoring, control, recording, and logging etc. for STP. This shall consist of PLC based SCADA system.
- All the Treatment Units including SBR/Cyclic Activated Sludge Process etc. shall be designed for manual & automatic operation through PLC and SCADA based system with PC based systems and peripherals. Provision shall be made to operate each

process Unit manually, if required. All the essential Drives shall be provided with standby arrangements.

- The control system shall be selectable to either “Local(Manual)” or “Automatic” or “Remote Manual” modes. Annunciation shall be provided on the HMI. All electrically actuated Valves shall be operated from HMI through PLC/SCADA.
- Operation & control philosophy of entire STP shall be suggested by STP vendor/technology provider and same shall be submitted to Engineer In-charge for their approval. For fully/semi automatic operation, Instrument Panel shall be provided for control and monitoring of STP.
- The Instrument Panel shall be pre-fabricated and floor mounted type.
- The Panel shall consist of minimum following devices in addition to clause
 - a) PLC with integral alarm annunciator & all required hardware and software
 - b) PC based SCADA system with all required hardware, software and peripheries.
 - c) Power supply modules.
 - d) Surge protection units.
 - e) Indicator for level, pressure and flow.
 - f) Selector switches for selection of Normal mode, flush mode, score mode and drives and various other modes as per process design requirements.
 - g) Push buttons.
 - h) MCBs.
 - i) Any other item required for functioning of the system.
- Programmable Logic Controller (PLC)

Codes and Standards

PLC shall comply with the following codes and standards:

- International Society of Automation (ISA)
 - National Electricity Manufacturers Association (NEMA)
 - International Electro-technical Committee (IEC)
 - American National Standards Institute (ANSI)
 - The Institution of Electrical and Electronic Engineers (IEEE)
-
- Design and Construction Requirements:
 - a) PLC shall be provided as a standalone controller to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

- b) PLC shall comprise of necessary processors, input/output (I/O) modules, communication interface modules, power supply modules, prefab cables etc.
- c) PLC shall have the following attributes as a standalone controller:
 - i. It shall carry out sequential operation of STP based on process requirements.
 - ii. It shall carry out sequential start/stop logic implementation for operation of the pumps and motorised valves.
 - iii. It shall accept downloaded program from a programmer.
 - iv. It shall have different functional modules to perform the desired functions
 - v. It shall scan the inputs in time cycles and update the status of inputs/outputs
 - vi. It shall have relays, counter/timer functions, internal registers/ flags, watch dog timer, set/reset facilities, up-down counter etc.
 - vii. It shall have a provision for spare input and output modules.
- d) The PLC system shall be expandable and shall be modular in construction so as to carry out the future expansion. PLC shall be microprocessor based with state of the art technology. System components shall be carefully chosen so that the reliability of the PLC shall be high. PLC shall use standard bus protocols and structures for communication within and outside the system. In case of system failure or power supply failure all the outputs shall attain pre-determined fail safe condition. Spurious signals shall not cause equipment operation.

➤ Central Processing Units

- a) The Central Processing Unit (CPU) shall be high performance processors with modular configuration suitable for real time process application. High inherent reliability, self checking, error-recovery and trouble-shooting features shall be source of the features of CPU.
- b) Automatic restart of the system on resumption of power shall be provided.

➤ Memory Unit

- a) Memory unit shall comprise of highly reliable memory chips which are industry standard, proven design with fast random access and suitable for operation in process environments. Main memory shall be modular and facility shall be provided for up-gradation and expansion of memory to meet future demands.
- b) Sufficient program memory and data memory space shall be provided. System initialization and application software shall be stored in EEPROM with necessary hardware. Running data shall be stored in a RAM with internal battery back-up. The battery back-up provided shall last for at least one month with life of battery a

minimum of 3 years. Appropriate programs for application software modification shall be provided.

- c) At least 20% extra memory space shall be provided over the actual requirements.

➤ Input/ Output Modules

- a) Standard rack mounted I/O modules with plug-in cards shall be provided. Field wiring shall be terminated in screwed terminal and interconnected to the processor I/O system with pre-fabricated cables with plug-in type connectors.
- b) 20% extra points of installed capacity for each type of input shall be provided as spares and shall be wired to the terminal block of the control panel. Provision shall be made for future expansion of extra I/O modules.
- c) Some of the common features of the I/O modules shall be as follows :
 - i. All inputs shall be terminated with input protective network and necessary isolating barriers.
 - ii. Filters for noise rejection.
 - iii. Provision for isolation of faulty channels.
 - iv. Test points and fault indication LEDs shall be provided to carry out module testing.
 - v. Surge withstands facility as per IEEE standards.
 - vi. All the modules shall be of addressable type.
 - vii. Protection for continuous overload up to 200% of all input ranges.
 - viii. Fuse protection and fuse failure detection.
 - ix. Internal battery backup.

➤ Software

- a) The online real time operating system supplied shall be proven for similar application and shall be able to support all the equipment/peripherals.
- b) Software shall support various mode of operation of the STP automatic / manual & various modes as per process requirements & shall be upgradable at any time during O&M period. Software (HMI, SCADA & other required software's) licenses shall have lifetime validity.
- c) All graphics for STP operation and controls.

➤ PLC Programming

- a) The PLC programming software shall be Windows based user friendly package. The software shall be supplied along with its documentation (hard copy as well as soft copy). The software shall have facilities for:
- carrying out program revision and management of these revisions
 - insertion of comprehensive program subroutine and rung comments
 - search and find and search and replace 'contacts' and 'coils'
 - simulation functions and testing of the program by changing the status of contacts and monitoring the outputs
 - preparation of coil and contact list and their locations and memory maps
 - make system backup copies while the system is online
 - upload and down load programs to the PLC online
 - carry out line maintenance and fault finding on the PLC
- b) The PLC programming shall be prepared using the PLC manufacturer's programming software package only. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation.
- c) The PLC shall be commissioned using RAM memory storage modules which shall be replaced with an EEPROM when testing is complete.

1.10.1 Technical Particulars

Sr. No	DESCRIPTION	REQUIREMENT
1	Type of Control system	Programmable Logic Controller (PLC)
2	Offered PLC System configuration and PLC system hardware	Latest system available / being supplied in the international market by the manufacturer with proven performance record for the similar type of application
3	Operating System windows based	Windows -XP/7 or latest.
4	Hierarchical protection for operator & engineer functions	Multi-level security required
5	UPS – Input-415V AC, 3Ø, 50 Hz Output- 230 V AC, 1Ø, 50 Hz	UPS of adequate capacity with battery back-up of min. 1hour (SMF Nickel-Cadmium batteries).
6	No of UPS feeders (outgoing)	Bidder to indicate
7	UPS sizing	Bidder to indicate. Adequate capacity UPS considering 30 % spare load.
8	UPS Battery back-up time	Min. One (1) hour

Sr. No	DESCRIPTION	REQUIREMENT
9	Response time (Maximum) for Analog input	250 m sec
	RTD	1 sec
	Digital Input / output	25 - 50 m sec
	Loop cycle time inclusive of controller processing time	250 m sec (Analog); 100 m sec (Digital)
10	Auto switchover time to backup/redundant component at a) Processor level b) Communication level c) Power supply level	Instantaneous and bump-less (Bidder to indicate the time)
11	Card changeover, card wiring removal or communication cable change shall be possible on-line (PLC running) without causing any process interruption	PLC Card removal shall be hot swappable.
12	Display Call up time in HMI monitor	1 sec or better
13	Dynamic update time of parameters in the HMI monitor for measurement and control	1 sec. or better
14	Spare capacity required in the control processor considering spare I/O channels and future I/O modules to be located in the spare I/o slots	Minimum 20 %
15	Output status on controller failure	Configurable in engineering station
16	Output status on power supply failure	Configurable for switching to fail safe mode
17	Status indication for each channel in DI / DO card	LED indication required
18	Power supply healthiness status in all modules	LED indication required
19	Optical Isolation with IPR for DI / DO	Required
20	Galvanic isolation for AI / AO	Required
21	Fuse Protection for AI / DI modules	Required

Sr. No	DESCRIPTION	REQUIREMENT
22	Fused terminals with LED indications for each DO and also for Power supply to PLC	Required
23	All I/O module status monitoring (Channel & Module level) in PLC system HMI & shall be from same processor family.	Required
24	Self-diagnostics for all PLC modules	Required
25	Control processor with floating point arithmetic capability	64 bit processor
	Capacity of RAM	2 MB minimum
	Spare capacity in RAM	Minimum 50 % including spare I/Os
	Processor Redundancy	Required. Dual redundant hot stand-by, Physical cable connectivity between primary and secondary controllers, loading of programs in primary controller alone.
	Power supply source redundancy with Auto changeover scheme.	Required. Shall be implemented at each PLC side.
	Power supply module redundancy in the PLC panel	Required
	Communication module redundancy	Required
26	Failure of communication module/ data bus/ communication bus/Power supply module shall not lead to change over of Processor/CPU	Required
	Network & Network module redundancy	Required
	Hot redundant connectivity between processor to I/O rack	Required
27	Primary and secondary indication on controllers	LED indication & also in MMI required
28	Memory expandability	150% of offered capacity
29	RAM with Battery back up	Minimum 72 hr without power.

Sr. No	DESCRIPTION	REQUIREMENT
	Supply of Flash RAM for memory /Program retention	Required
30	Closed loop control	Redundant I/O system
31	Open loop control (Logic , protection & interlock)	Non-redundant I/O modules
32	Maximum number of channels in I/O modules - Analog I/O modules RTD, Thermocouple Digital I/O modules	8 Channels (Differential type) 16 Channels 16 Channels
Input – Output Philosophy		
	Motor	<u>Digital Input:</u> Local / Remote Selector-1 No Run Feedback- 1 No Stop Feedback- 1 No Over Load Feedback- 1 No <u>Digital Output:</u> Start Command- 1 No Stop Command-1 No <u>Analog Input:</u> Speed Feedback (Applicable for VFD driven Pump)-1 No Vibration Sensor Feedback(Applicable for MV Motor)- 6 Nos <u>Analog Output:</u> Speed Reference (Applicable for VFD driven Pump)-1 No <u>RTD Input:</u> Windings & DE / NDE Bearings Temperature (Applicable for motor having winding and bearing RTDs)- 8 Nos
	Pump / Blower	<u>Analog Input:</u> Pressure Transmitter- 1 No (wherever continuous Pressure monitoring is required) Flow Transmitter- 1 No (wherever continuous Flow monitoring is required)
	Motorized Valve	<u>Digital Input:</u> Local / Remote Selector-1 No Open Feedback- 1 No Close Feedback- 1 No

Sr. No	DESCRIPTION	REQUIREMENT
		Over Load Feedback- 1 No Torque Switch Feedback-1 no <u>Digital Output:</u> Open Command- 1 No Close Command-1 No <u>Analog Input:</u> Position Feedback (Applicable for Modulated Control Valve)-1 No <u>Analog Output:</u> position Reference (Applicable for Modulated Control Valve)-1 No
	Breaker	<u>Digital Input:</u> Local / Remote Selector -1 No ON Feedback- 1 No OFF Feedback- 1 No Master Trip Relay Operated- 1 No <u>Digital Output:</u> ON Command- 1 No OFF Command-1 No
	Transformer	<u>Digital Input:</u> Oil Level Low Alarm-1 No Oil Temperature High-1 No Oil Temperature Very High-1 No Winding Temperature High- 1 No Winding Temperature Very high-1 No Buchholz Alarm-1 No Buchholz Trip-1 No Pressure Relief Device Trip -1 No OLTC Fault-1 No
	Sump / Tank	<u>Digital Input:</u> Level Very High-1 No Level High -1 No Level Low-1 No Level Very Low-1 No <u>Analog Input:</u> Level Transmitter- 1 No (wherever continuous Level monitoring is required)
33	Power supply to the field transmitters	Analog input module shall drive the connected field transmitter on 2 wire loop
34	Interrogation voltage for Digital signals	24 V DC
35	Concept of I/O grouping	a) No two identical / similar equipment shall be grouped in

Sr. No	DESCRIPTION	REQUIREMENT
		<p>the same I/O module</p> <p>b) I/Os related to an equipment and I/Os related to its associated auxiliaries shall be connected to different modules.</p> <p>Inputs and outputs shall not be combined in a single module.</p>
36	USB ports on Operator station	4 nos.
37	DVD R/W drives on Operator Station	One(1)
38	Displays on HMI monitor	Process mimic displays, trend displays, system status, alarm displays, logs / reports etc. HMI software shall have minimum 100 pages with unlimited tags.
39	Minimum no of plant mimics configurable	100
40	Time activated logs	Periodic logs, shift report, daily report, status change log, Control system fault log
41	Operator Work Station (OWS)	<p>One no. Industrial grade OWS shall be considered.</p> <ul style="list-style-type: none"> - Intel I5/ I7, Minimum 3.6 GHz processor or latest - 22" LED Monitor - 8 GB RAM min or better - 1 TB HDD - ASCII keyboard - DVD R/W Drive - Workstation model - Original OS & antivirus
42	Engineering Work Station cum OWS	<p>One no. industrial grade EWS cum OWS shall be considered.</p> <ul style="list-style-type: none"> - Intel I5 / I7, Minimum 3.6 GHz processor or latest - 22" LED Monitor - 8 GB RAM min or better - 1TB HDD - DVD R/W Drive - QWERTY Keyboard

Sr. No	DESCRIPTION	REQUIREMENT
		<ul style="list-style-type: none"> - Workstation model - Original OS & antivirus
43	Annunciation System	Integral to the PLC
44	Printers	One A3/A4 size colour laser jet printer (600 DPI resolution) shall be provided
45	Hot Spare I/O modules	20 % (wired up & mounted) hot spare modules for each type of I/O module shall be provided in the panel
46	Spare Channels in each I/O Module used	20 % (wired up) spare channels over the entire population of each type of module.
47	Spare slots in the I/O rack (wired with connector)	20% additional slots/base in each rack shall be provided which shall be wired with connectors for future provision. This is in addition to the required 20 % (wired & mounted) hot spare modules.
48	Fuse with led indication for I/O channels	<ul style="list-style-type: none"> - Individual for analog signals - Group of max 8 for digital channels
49	PLC hardware	G3 rated
50	SER	SER in PLC is envisaged for electrical signal only.
51	Interposing Relays	24 V DC with freewheeling diode across the coil – Relay contact rating A at 230 V AC
52	Panels / Cabinets	Self Standing type with maximum height of 2200mm
54	Mechanical features	<ul style="list-style-type: none"> a) 2 mm thick CRCA steel sheet for panel walls. 3mm thick removable gland plate b) 2.5 mm thickness for double doors c) Panel - door switch

Sr. No	DESCRIPTION	REQUIREMENT
		d) Fans and louvers e) Paint as per RAL 7035 f) Automated panel Illumination by push buttons g) Suitable enclosure protection h) Anti-vibration pad of minimum 15mm thickness.
55	Panel Earthing	Safety earth for enclosure and Electronic earth for PLC system.
56	Control room	Air Conditioned.
57	Quality Assurance	As per quality plan to be approved by the Purchaser / Engineer
58	Inspection Requirements	Factory Acceptance Test & Site Acceptance Test as per procedure approved by the Purchaser / Engineer.
59	Communication	The communication shall be redundant between the control processors and HMI as well as across processors and transmission rate shall be minimum 100 MBPS/1GBPS through multi- port switch having FO ports, ensuring adequate number of spare ports. Also communication between control processors and I/O shall be redundant. PLC shall be provided with required number of MODBUS ports. PLC shall have time synchronisation facility with master clock directly connected to PLC cards.
60	Undertaking for Spares & support	OEM's undertaking shall be furnished for Spares & service support for minimum 15 years.
61	Make of PLC	As per Approved List.
62	Control Cabinets/ Consoles:	
	Type & Constructional Features	<ul style="list-style-type: none"> Indoor, Self Standing type with maximum height of 2200 mm Sheet Steel Thickness - 2.0 mm thick CRCA sheet for panel walls.

Sr. No	DESCRIPTION	REQUIREMENT
		3mm thick removable gland plate. <ul style="list-style-type: none"> • Pant Finish as per RAL- 7032. • Enclosure Protection - IP54 • Anti-vibration pad of minimum 15 mm thickness.
	Accessories	<ul style="list-style-type: none"> • Panel - door switch • Fans and louvers • Panel Illumination Lamps
	Consoles & Chairs	Consoles for OWS, EOWS & Printers. Two (2) nos. operator chairs (revolving type)
63	Software:	
	PLC Development License Software	Required
	SCADA Development License Software	Required
	SCADA Run Time License Software	Required
	Work Station Operating System License Software	Required
64	Air Conditioner:	
	Air Conditioner minimum 2 Ton, 5 Star Rating with Copper Tubing, Fittings & Accessories.	Required

➤ Uninterruptible Power Supply (UPS)

- a) A UPS with 60 minutes backup time shall be provided for the power supply of Instrumentation, Control & Automation system. The UPS shall have sealed maintenance free batteries and AC distribution board.
- b) The batteries shall be sized such that the maximum recharge time does not exceed 8 hours. Contractor shall furnish UPS sizing calculations for review and approval.

Sr. No	DESCRIPTION	REQUIREMENT
1	Input	415V, 3P / 240V 1P AC (to be decided during detailed engineering)

Sr. No	DESCRIPTION	REQUIREMENT
2	Output	230V AC, 50 Hz
3	UPS Capacity	*KVA (* KVA rating shall be finalized during detailed engineering)
4	UPS Battery back-up time	Minimum 60 min.(SMF NI-CD)
5	No of UPS feeders (outgoing)	As per system requirement.
6	UPS Type	Online, Double Conversion, Industrial
7	Rectifier Charger Type	SCR / IGBT Based
8	Static Inverter Type	SCR / IGBT Based
9	Static Transfer Switch Type	SCR-SCR Based
10	Bypass	Solid State Static Bypass with Isolation in matching cubical
11	Manual Bypass Switch Type	Change over
12	Battery Type	SMF NI-CD
13	Isolation Transformer	Required, Built in within UPS- Input Side & Output Side
14	Degree of Protection	IP41 or better
15	Cable Entry	Back Side Bottom
16	Communication - SNMP Card & MODBUS	Required
17	Potential Free Contacts	<ul style="list-style-type: none"> - Rectifier Trip - Inverter Trip - Load on Battery - Battery low Pre-alarm - Load on Static Bypass - One Relay contact for each, Rating – 1A/230 Vac OR 2A / 12 Vdc
18	Drawings / Documents	SLD, GA, Power & Control Wiring Diagram & Foundation Details, Type Test Certificate, FAT/SAT Procedure
19	Reference standard	IEC 62040-3 or equivalent

➤ Surge Protection Devices:

- a) Surge Protection Devices (SPDs) shall be provided for each signal and power loop for field instruments located outdoor. One SPD shall be provided in the field near transmitter and the other SPD of the loop shall be mounted in the control panel. SPDs shall be suitable for withstanding the surge arising out of high energy static discharge / lightning discharges and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Transorb, zener diodes, varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require

negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPDs shall be self resetting to minimise the down time of the measurement loop. SPDs shall have minimum surge rating of 10 KA.

- b) SPDs shall have a weather proof casing and shall be suitable for field / back of panel mounting as applicable. There should be total isolation between input, output and ground terminals.
- c) Surge protection devices (SPDs) shall be provided at the control panel end of all instrumentation cables for the instruments located outside the building, in addition to the SPD at the instrument end. The SPD s shall be grouped in a specific area within instrument panel.

1.11 Control Philosophy for different Units.

1.11.1 General Control Philosophy

- a) This section describes the general control philosophy that the Contractor shall follow for STP process proposed by him for this contract. These requirements herein are in general. The bidders/contractors shall submit detailed and specific versions of the control philosophy and the functional design specifications in both the bidding and design stages.
- b) The contractor shall note that STP shall be designed to operate in fully automatic (auto mode) of operation at all given times. In the event of failure of the same, facility shall be provided to operate the plant in manual mode till such time the auto mode is again available. Design shall incorporate level, flow and pressure interlocks to ensure plant is operated in a safe condition at all times and to ensure maximum uptime. Contractor shall note the importance of this requirement.
- c) The STP included in this contract shall comprise items, components, and unit processes as described in the bid documents, and shall include but not be limited to all supporting and ancillary equipment, accessories, instrumentation, controls, automation, and any and all other components required for proper, easy, and automated operation and functioning and for accomplishing the specified performance objectives.
- d) The STP control system shall include a dual hot standby main plant PLC. Typically, signals from individual or isolated field instruments within a physical distance of approximately 150 meters from the main plant PLC shall be transmitted directly to the main plant PLC. Signals from instrument groups belonging to common unit processes, control loops, or package systems, or signals originating more than 150 meters away from the main plant PLC, shall typically be transmitted to RIO (Remote Input/Output) panels or local control panels dedicated to the respective unit processes, control loops, or package systems.

- e) The control logic shall be programmed by the system supplier into the system PLC. However, all signals received or generated by the system PLC, including alarms, shall also be transmitted to the STP SCADA HMI for monitoring, and operator shall have option to provide all required operator input (including but not limited to set points, start/stop control, open/close control, speed control, etc.) either at the system PLC or at the STP SCADA HMI.
- f) The following shall be provided in the PLC control room at a minimum:
 - i. Dual redundant SCADA system
 - ii. Historian system
 - iii. Network printers and managed Ethernet switches
- g) The Contractor shall develop a logical, meaningful, modular, and expandable tag numbering system for all control elements, including but not limited to equipment, instruments, actuators, and control loops. The numbering system shall be such that components of the tag number provide immediate indication of the type of element (e.g. pump, blower, gate, valve, mixer, flow meter, etc.), its location and/or unit process, and the number of similar modular units proposed. The system shall allow for easy modifications such as future addition of units for expansion. The Contractor shall submit the tag numbering system for Engineer's review and approval prior to implementation.
- h) The Contractor shall submit for Engineer's review and approval I/O lists in each hierarchy level such as field level, local control panel, local electrical/MCC room level, STP PLC control room level. The I/O list shall be categorized into discrete input/output signals, analog input/output signals, signals through field bus, and signals through LAN communication at each level. The list shall also contain process/equipment status and alarm/fault signals, commands to process, and log items for historical records. All alarms shall be visually and prominently indicated at the local panel, the STP SCADA HMI. Critical alarms shall also be annunciated with flashing/strobe lights and audio sirens at select locations at STP site. The Contractor shall submit full alarm schedule details including designation of critical alarms and annunciation locations for Engineer's review and approval prior to implementation.

1.11.2 Sewage Treatment Plant shall consist of following components

- a) Fine Screens
 - i. The raw sewage will be delivered to the fine screen inlet channel.
 - ii. Gates with manual hand-wheel operators shall be installed both upstream and downstream of the fine screens so that each screen channel can be isolated for maintenance.

- iii. The control and instrumentation philosophy for fine screens. Level transmitters shall be installed both upstream & downstream of the fine screen. When the difference in upstream & downstream level reaches a set value, a screen cleaning cycle shall be initiated. The fine screens shall be equipped with flushing spray nozzles controlled by solenoid valves. The flushing valve shall open/close in the auto mode in linkage with the associated screen running condition. The fine screens can be operated manually by the operator at a local control panel located adjacent to the equipment during trouble shooting or maintenance. The flushing valve will also be operated manually by the operator at the above local control panel.
- iv. Removed screenings/debris will be washed prior to being disposed into the skip through belt conveyers.

b) Fine Screenings Conveyor

- i. The conveyor shall operate in an auto mode in association with the fine screens. The conveyor will also be operated manually by the operator at the local control panel located adjacent to the equipment during trouble shooting or maintenance, or at the STP SCADA HMI.

c) Grit Collectors

- i. The grit collectors will be installed in the grit chambers to transport settled grit into a pit at the outer edge of the basins by a rotating scraper. The pit also serves as the bottom of the grit washer/classifier.
- ii. The de-gritted sewage overflows to a partial flume and then to the Aeration Basin inlet distribution structure.

d) Grit Washers/Classifiers

- i. The grit washers/classifiers shall be manually operable at the local control panel located adjacent to the equipment during troubleshooting or maintenance, or at the STP SCADA HMI. The flushing valves shall be manually operable at the local control panel located adjacent to the equipment during troubleshooting or maintenance, or at the STP SCADA HMI.
- ii. In auto mode, the grit washers/classifiers shall run continuously. The flushing valve shall open/close automatically in the auto mode in linkage with the grit washer/classifier.

1.11.3 Biological Treatment Process

To maintain the DO level in the aeration basin, necessary controls shall be provided at local panel and SCADA. Based on the technology proposed by the bidder, necessary automation and control system shall be provided and approved by the Employer along with P&ID.

1.11.4 Process Air Blowers and Aeration Basin Air Flow Control Valves

- a) Control and instrumentation philosophy is presented below separately for Batch reactors and Continuous flow reactors. For batch reactors, each aeration basin under aeration shall be served by one or more blowers dedicated to that basin alone for the duration of the aeration phase. In contrast, for later processes, all blowers shall discharge to a common header which shall distribute the air flow between all operating aeration basins.
- b) The process air blowers shall be operable manually at a local control panel located adjacent to the equipment, or remotely at the STP SCADA HMI. Remote operation shall be operator-selectable as MANUAL, AUTO, or CASCADE for STP site. For batch reactors, an additional TIMED mode shall be provided.
- c) DO probe holders and cable connectors shall be provided at each aeration basin, to be reviewed and approved by Engineer based on Contractor's submittals. The operator shall have the option of using any one of these locations for each aeration basin, effectively generating a single DO signal per basin.
- d) For simplicity, blower sequencing requirements specified below in terms of increases or decreases in blower motor speed are stated for PD blowers with VFDs.

For open technology, in addition to the minimum requirements described in this section, any and all additional controls, functionality, or features considered by the bidder proposed technology supplier to be essential for proper and efficient operation of the system shall also be provided.

1.11.5 Return Activated Sludge (RAS) and Waste Activated Sludge Pumps

- a) Under normal operation, the RAS pumps shall run continuously in remote auto mode.
- b) In auto mode, two operator-selectable sub-modes shall be provided – FLOW and RATIO.
- c) In either mode, the total RAS/SAS flow shall be maintained within operator-specified overriding minimum and maximum values.
- d) The RAS pumps shall be manually operable at a local control panel located adjacent to the equipment, or at the STP SCADA HMI.

1.11.6 Surplus/Waste Activated Sludge (SAS/WAS) Valve

- a) Under normal operation, the SAS valve shall be controlled by the PLC in remote auto mode. In remote auto mode, three operator-selectable sub-modes shall be provided for control of the SAS valve – CONTINUOUS, TIMED, and TOTALIZED.
- b) In the CONTINUOUS mode, the valve shall be modulated to maintain an operator-specified flow rate set-point.

- c) In the TIMED mode, the SAS valve shall be opened and closed according to an operator-specified timer program. When the valve is not closed, the valve and flow rate shall be controlled as in the CONTINUOUS mode.
- d) In the TOTALIZED mode, the SAS valve shall be opened at an operator-specified start time once per day, and the valve and flow rate shall be controlled as in the CONTINUOUS mode. The valve shall be closed when an operator-specified total SAS volume has been pumped.
- e) The SAS valve shall be manually operable at an actuator interface control panel, or at the STP SCADA HMI.

1.11.7 Disinfection

- a) Chlorine Disinfection
 - i. Under normal operation, the chlorinators shall be controlled in remote auto mode. In remote auto mode, two operator-selectable sub-modes shall be provided – DOSE and ORP.
 - ii. In DOSE mode, the chlorine gas flow control valves of the chlorinators shall be automatically modulated to maintain an operator-specified chlorine dose set point. The operator-specified set point shall be multiplied by the plant influent flow and divided by the number of chlorinators in service to generate chlorine mass flow rate set point per chlorinator.
 - iii. In CASCADE mode, the ORP error (difference between an operator-specified ORP set point and measured ORP value) shall be used to generate a modulating signal. This modulating signal shall be used to automatically generate a variable chlorine dose set point. The chlorine gas flow control valves of the chlorinators shall be automatically modulated to maintain the automatically generated variable chlorine dose set point. The automatically generated variable set point shall be multiplied by the plant influent flow and divided by the number of chlorinators in service to generate chlorine mass flow rate set point per chlorinator.
 - iv. The chlorinators shall be manually operable at the local control panel located adjacent to the equipment and at the STP SCADA HMI.
- b) Chlorine Ejector
 - i. Under normal operation, the chlorine injector shall run continuously in remote auto mode in linkage with the chlorinators.
 - ii. The chlorine injector shall be manually operable at the local control panel located adjacent to the equipment or at the STP SCADA HMI.

1.11.8 Solid Processes

- a) Sludge Thickener Mechanisms
 - i. The sludge thickener mechanisms shall be manually operable in the field at the local control panel, or remotely at the STP SCADA HMI. Alarms shall be generated on operator-selectable values for high torque and high-high torque.

High-High torque shall also shut down the drive motor via a hardwired interlock. The thickener motor and drive shall be capable of reversing direction using a pushbutton switch that is normally off and that the operator can push and hold for the duration of the desired reverse rotation.

b) Thickener Feed Pumps

- i. The thickener feed pumps shall be manually controllable (start, stop, and speed) at a local control panel located adjacent to the equipment and at the STP SCADA HMI.
- ii. Under normal operation, the thickened sludge pumps shall be controlled by the PLC in remote auto mode. In auto mode, the pump speed shall be automatically controlled to maintain an operator-specified thickener feed flow set point. The total flow rate set point shall be divided by the number of thickeners in service to generate a flow rate set point per thickener.

c) Dewatering Feed Pumps

- i. Under normal operation, the dewatering feed pumps shall run automatically in remote auto mode when given a permissive by the dewatering centrifuge PLC. In auto mode, the pump speed shall be automatically controlled to maintain an operator-specified centrifuge feed flow set point.
- ii. The dewatering feed pumps shall be manually operable at the local control panel located adjacent to the equipment and remotely at the STP SCADA HMI.

d) Dewatering Centrifuges /Filter Press

- i. The dewatering centrifuges/filter press shall be manually operable at the manufacturer-provided local control panel located near the equipment and remotely at the STP SCADA HMI.
- ii. Under normal operation, the centrifuges shall be automatically controlled in remote auto mode. In auto mode, the centrifuge/filter press operation shall be fully controlled by the manufacturer-provided and manufacturer-programmed PLC incorporated into the manufacturer-provided local control panel. The feed sludge flow rate signal shall be provided to this PLC. The PLC shall use this signal and the manufacturer-programmed control logic to optimize centrifuge performance and operation. Operator shall have the option of providing inputs such as set points as well as monitoring all operational status signals, including alarms, at the local panel as well as remotely at the STP SCADA HMI.

e) Dry Polymer Feeder

- i. Under normal operation, the dry polymer feeder shall be controlled automatically in remote semi-auto mode when initiated by the operator at a local control panel adjacent to the equipment. The feeder valve shall be

- automatically modulated to maintain an operator-specified volumetric dry polymer feed rate for operator-specified time duration. Dilution water flow control valves shall also be automatically modulated to maintain an operator-specified dilution water flow rate for the same duration as the dry polymer flow – in linkage with the dry polymer feeder. Both the dry polymer feeder valve and the dilution water valve shall be automatically closed either when the operator-specified time duration has elapsed, or the level in the polymer batch tank reaches an operator-specified high level, whichever occurs first.
- ii. The polymer feeder and the dilution water flow control valves shall be manually operable at the local control panel located adjacent to the equipment and remotely at the STP SCADA HMI.
- f) Polymer Batch Tank Mixers
- i. Under normal operation, the polymer batch tank mixers shall operate in remote auto mode. In auto mode, the mixers shall be automatically started when the tank level reaches an operator-specified minimum level and shall be automatically stopped when the tank level falls below the minimum level.
 - ii. The polymer batch tank mixers shall be manually operable in the field at the local control panel adjacent to the tanks and remotely at the STP SCADA HMI.
- g) Polymer Metering Pumps
- i. Under normal operation, the polymer metering pumps shall operate in remote auto mode. In auto mode, an operator-specified polymer dose set point shall be multiplied by the measured dewatering feed sludge flow rate and by an operator-specified sludge solids concentration and divided by an operator-specified polymer solution concentration to generate a polymer solution flow rate set point.
 - ii. The polymer metering pump stroke and speed shall be automatically controlled to maintain the system-generated polymer solution flow rate set point.
 - iii. The polymer metering pumps shall be manually operable at the local control panel located adjacent to the equipment and remotely at the STP SCADA HMI.
- h) Dewatered Sludge Conveyor
- i. Under normal operation, the dewatered sludge conveyor shall operate in remote auto mode in linkage with the centrifuges. In auto mode, the conveyor shall be running when any of the centrifuges is running.
 - ii. The dewatering sludge conveyor shall be manually operable at the local control panel adjacent to the equipment and remotely at the STP SCADA HMI.
- i) Dewatered Sludge Hopper

- i. The dewatered sludge hopper shall be operable manually only at the local control panel located adjacent to the equipment. No remote or automatic operation shall be provided.
- ii. The hopper discharge gate shall be equipped with open and close position limit switches. The gate position as well hopper weight signals shall be transmitted to the local hopper control panel as well as to the STP SCADA HMI. The centrifuges/filter press shall automatically be shut down if the hopper weight exceeds an operator-specified maximum value.

1.12 Quality Assurance, Inspection And Testing:

The automation system shall be designed, selected & supplied ensuring proper quality & performance. Vendor's procedures for Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) shall be submitted at least 60 days prior to the scheduled conduction of these tests for review/acceptance.

The proposed FAT & SAT procedures of Vendor shall be reviewed and modified as required to generate mutually agreed & finalized procedures, based on which these acceptance tests will be performed and supervised by authorized agency of purchaser.

All system hardware & software used for testing shall be complete as specified and shall use actual equipment to be shipped to the site as per scope.

The test equipment, meters, instruments etc. used for testing shall be calibrated at recognized test laboratory at regular intervals and valid certificates shall be made available to the purchaser at the time of testing. The calibrating instruments used as standards shall be traceable to international standards. Calibration certificates for test instruments shall be produced from a recognized laboratory for the purchasers consent in advance of testing and if necessary the instruments shall be recalibrated or substituted before the commencement of the test.

1.12.1 Factory Acceptance Tests (FAT):

The factory acceptance test shall be held at manufacturer's works. Prior to the FAT, all the equipment shall be fully assembled, wired and properly connected & tested to establish all the specified features & functional requirements of the systems.

During FAT, functional integrity of the system hardware and software shall be tested & demonstrated. All the necessary simulation kits as may be required for testing of software shall be arranged.

Bidder shall perform functionality tests of complete system and satisfy himself of the results before giving notice regarding readiness of the system and its availability for FAT. Such notice shall be given minimum 15 days before the scheduled start of the FAT.

The factory acceptance tests shall include visual and mechanical testing to establish correctness, completeness, good workmanship and functional testing.

The tests shall systematically, fully & functionally establish performance of all the hardware & software in presence of authorized representatives. All the sub-systems shall be interconnected to simulate, as close as possible, the total integrated system. Each test carried out shall be documented. Simulators shall be used for simulating field inputs. Any deficiency or problem faced shall be clearly brought-out and corrected.

Before start of the FAT, the complete integrated system shall be kept powered on for 72 Hrs.

All assemblies shall be aligned & adjusted and all test results shall be documented.

The automation system shall be shipped to site only after successful completion of FAT and receipt of dispatch clearance from purchaser.

1.12.2 Site Acceptance Test (SAT)

At site, the system shall be properly installed taking care of manufacturer's recommendation, after which Site Acceptance Tests (SAT) shall be carried out taking into the actual field instruments/ equipment in the loops.

The Site Acceptance Test shall be held at site after the system has been installed as per the finalized SAT procedures. The tests shall be witnessed by purchaser.

The minimum tests to be carried out shall be as indicated in table below.

A log of all failed/ mal-operating components /modules in a sub-system shall be maintained by Vendor, with description of the affected components /modules, cause of failure, effect of failure on the sub-system and number of hours of operation before it failed. This will start from the date of powering on of the system for cold commissioning.

1.13 Test & Acceptance Criteria:

1.13.1 Test Criteria:

Following tests shall be performed as a minimum for automation system, during both FAT & SAT, in presence of authorized representatives and documented test results shall be compiled:

FAT=Factory Acceptance Test; to be performed at Vendor's workshop. SAT= Site Acceptance Test; to be performed at site. √= Complete test; 100% of devices/ functionality will be tested. S = Sample test All the necessary simulation kits as may be required for testing of software shall be arranged. Acceptance of any equipment or the exemption of inspection shall in no way absolve the Vendor of the responsibility for delivering the equipment meeting the entire requirement specified in this specification and also as may be required for satisfactory operation of the process.

Sl.	Test Description	FAT	SAT
1.	Check of supply completeness	√	√
2.	Visual & dimensional check	√	√
3.	Check of complete system configuration loading	√	-
4.	Check of system diagnostic features. These shall include failure of any sub-system, module, power supply, interface unit, failure of transfer to redundant module on main module failure etc.	√	√
5.	Power-off and power-on of any single unit	√	√
6.	Test of alarm system	√	√
7.	Check of correct functionality of keyboards	√	√
8.	Testing of proper working of the printers	√	√
9.	Simulation of power failure and restart. Self-booting up of system configuration & program after power restoration.	√	√
10.	Analog / digital input / output check	√	√
11.	Check of scan time for PLC	√	√
12.	Check of scan time, screen update time and loop cycle time.	√	√
13.	Check of loop configuration for correct entry of ranges, limits etc.	√	S
14.	Check of HMI displays (all kind of displays)	√	S
15.	Checking of HMI screen refresh rate, data base update and display call-up time.	√	S
16.	Check of system internal loading (processor, communication system etc.)	√	-
17.	Check of various log formats, shutdown reports etc.	√	S
18.	Demonstration of all PLC system builder functions including addition/deletion of an input/output, addition/deletion of a rung or an element in a rung generation of dynamic graphics and other views, report generation etc.	√	√
19.	100% checking of logic configured in the PLC by connecting switch/lamp at input/output.	√	-

Sl.	Test Description	FAT	SAT
20.	<p>Redundancy check for PLC including correct changeover of the back-up unit in case of failure of main unit. These shall be applicable for following:</p> <p>CPU Redundancy</p> <p>CPU Power supply redundancy</p> <p>Each CPU to host system communication interface & communication link redundancy</p> <p>I/O subsystem to processor system communication redundancy</p> <p>I/O rack power supply redundancy</p>	√	√
21.	Checking of output status on processor failure for PLC & checking of first-out alarm generation.	√	√

1.13.2 Acceptance Criteria:

Automation system shall be suitable to meet the below minimum acceptance criteria, which are to be demonstrated by the successful bidder during testing of the system.

Sr. No.	Description	Criteria
1	Availability of Automation System	99.8% [calculated over a period of seven (7) working days]
2	HMI screen refresh time	1 sec
3	I/O scan time/data up gradation time	<p>250 milisec for analog signals</p> <p>100 milisec for digital signals</p> <p>Priority processing shall be provided for the data requiring faster scan rate</p>
4	Network bandwidth utilization (Average of 5 minutes) (To be measured over	< 10%

	continuous period of 8 hours)	
5	Spare (free) memory capacity available (for system, server & PCs, PLC controller)	50% (after commissioning)
6	Spare I/O capacity of each type at each location, spare ports of networking switches	20% (after commissioning)
7	CPU loading (5 minutes average)	50% (after commissioning)

1.14 Spares & consumables:

1.14.1 Commissioning spares:

Bidder shall submit a list of spares & consumables required for start-up and commissioning of the plant, equipment, systems etc. which will be supplied as part of scope. The list shall broadly include spares & consumables for the field instrumentation items, as per manufacturer's recommendation and one no. of each type of I/O module of the PLC based automation system, with respective description & quantities. In addition, any other spare & consumable, required during these activities, shall also be supplied by bidder under his scope.

1.14.2 O&M Spares:

As specified in the Scope of Work, Bidder shall keep with himself necessary spares during entire period of Operation & Maintenance for repair, replacement, maintenance etc. of ICA equipment. The list of recommended spare parts shall be provided by the bidder but shall not consider in price bid. Mandatory spare parts shall be inclusive of quoted price.

1.15 Tools and Tackles:

Bidder shall include in his offer and provide all the special tools and tackles for erection, testing & maintenance of the instrumentation & automation system, as required for proper functioning and maintenance system

ABBREVIATIONS USED

ABS	Acrylonitrile butadiene styrene
AC/DC	Alternating Current / Direct Current
BOD	Biochemical Oxygen Demand
CCR	Centralized Control Room
CCT	chlorine contact time

COD	Chemical Oxygen Demand
CPU	Central Processor Unit
CUM	Cubic Meters
DO	Dissolved Oxygen
DPM	Digital Pannel Meter
EIA / TIA	Electronic Industries Association / Telecommunications Industry Association
FRLS	Fire Retardant Low Smoke
FRP	Fibre-reinforced plastic
HART	Highway Addressable Remote Transducer
HDPE	High Density Polyethelen
HMI	Human Machine Interface
I/O	Input / Output
ICA	Instrumentation, Control & Automation
IEC	International Electrotechnical Commission
IP	Ingress Protection
ISO	International Standards Organization
IT	Information Technology
LAN	Local Area Network
LCD/LED	Liquid Crystal Display / Light Emmiting Diode
MCB	Miniature Circuit Breakers
MLD	Million Litres per Day-
NO / NC	Normally Open / Normally Closed
OPC	OLE for Process Control
ORP	Oxidation Reduction Potential
OS	Operator Station
OSI	Open Systems Interconnect
P&ID	Piping & Instrumentation Diagram
PLC	Programmable Logic Controller
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
RAS	Returned Activated Sludge
RTU	Remote Terminal Unit
SAS	Surplus Activated Sludge
SCADA	Supervisory Control and Data Acquisition System
SPD	Surge Protection Devices
SS	Stainless Steel
STP	Sewage Treatment Plant
TCP/IP	Transmission Control Protocol/Internet Protocol
TE	Treated Effluent
TSS	Total suspended solids
UPS	Uninterrupted Power Supply
VFD/VSD	Variable Frequency Drive/ Variable Speed Drive
