RAJKOTMUNICIPALCORPORATION
INVITATION FOR BIDS / TENDER
e-Tender Notice

The e-Tenders are invited by Rajkot Municipal Corporation, Water Works Department, Dr. Ambedkar Bhavan, Central Zone, Dhebarbhai Road, Rajkot-360001 from the experienced contractors registered in '**AA**' Class / Equivalent Class in GWSSB / State Government / Central Government for following works, under Rajkot Water Works Project.

Sr. No	Name of work	a) Estimated Cost b) Amount of EMD c) e-Tender fee d)Time limit for completion of work
1	**ENGINEERING, PROCUREMENT, CONSTRUCTION, COMMISSIONING AND 2 YEARS OPERATION & COMPREHENSIVE MAINTENANCE OF 25MLD CAPACITY WATER TREATMENT PLANT AT EXISTING NYARI WTP SITE, RAJKOT.** **e-Tender No.: RMC/2024/WW/25MLD WTP/NYARI**	**a) Rs. 7,31,89,770/-** **b) Rs. 7,31,897/-** **c) Rs. 15,000/-** **d) 18 months including monsoon period and 3 months successful trial run**

:: **Milestone dates of e-Tendering** ::	
1 Downloading of e-Tender documents	29-01-2024 to 19-02-2024 up to 17.00 Hrs.
2 Pre-bid Meeting (Queries also to be submitted by e-mail ID kpdethariya@rmc.gov.in & sbchhaiya@rmc.gov.in before 13-02-2024 up to 13:00 Hrs.)	13-02-2024 at 11.00 Hrs. at Central Zone Office -RMC
3. Online submission of e-Tender	19-02-2024 up to 18.00 Hrs.
4. Physical submission of EMD, Tender fee, Documents required for pre-qualification and other necessary documents.	20-02-2024 up to 18.00 Hrs.
5. Verification of submitted documents (EMD, Tender fee, Documents required for pre- qualification and other Necessary documents.)	23-02-2024 at 10.30 Hours onwards
6. Opening of online Primary Bid (Technical Bid)	21-02-2024 at 10.30 Hrs. onwards
7. Opening of online Commercial Bid (Price Bid) for technically qualified bidders only.	26-02-2024 at 10.30 Hrs. onwards (If possible)
8. Bid Validity	180 Days

1. All bidders must submit tender fee and Bid Security (EMD) as above either directly deposited in Account No. 01018640000035 (Rajkot Municipal Corporation) IFSC Code HDFC0000101 or submit at the below mentioned address along with physical submission of bid documents in form of Demand draft in favour of "Rajkot Municipal Corporation", Rajkot, from any Nationalized Bank or Scheduled Bank (except Co-Operative Bank) in India. Bid Security (EMD) may also be submitted in the form of irrevocable & unconditional Bank Guarantee (valid for min. duration of bid validity period) in

favor of "Rajkot Municipal Corporation", Rajkot, from any Nationalized Bank or Scheduled Bank (except Co-Operative Bank) in India. Also, Address proof of registered office and ID proof shall have to be submitted along with physical submission of required documents.

Office of the Add. City Engineer [CZ]
Water Works (Projects)
Rajkot Municipal Corporation, Central Zone
Dr. Ambedakar Bhavan, Dhebarbhai Road
Rajkot-360 001.
Tel.: +91 96247 38181
E-mail: kpdethariya @rmc.gov.in

2. The pre-qualification requirement is as under:

i) Financial Criteria:

a) The bidder shall have the **financial capability** and having an **average annual turnover** of **last Seven years**, ending 31st March of the previous financial year (i.e. 2022-23), should **not be less than 50% of the estimated tender cost.** Bidder to enclose reports on its financial standing, such as profit and loss statements and auditor's reports, for the last seven financial years.

b) **Working capital** (to be demonstrated by the bidder in form of confirmed credit line from reputed Bank or the bidder's own audited financial statement taking into account current commitment) should not be less than **25%** of the estimated tender cost.

c) Bidder shall have a **solvency** equal to or more than **Rs. 300.00 lacs**. Certified banker's statement not older than 6 months shall be attached.

d) The contractor shall have a registration with State / Central Government or State Water Supply Boards or in Municipal Corporation in **'AA' Class** / Equivalent Class. Supporting documents to be submitted in hard copy

e) Available Bid Capacity - ABC must be more than the estimated tender cost.

Note:

1. Available Bid Capacity (ABC) will be derived by the following method.

   ABC is calculated as ABC=2*A*N-B
   Where,
   - A = Maximum value of works executed in any one year during the last Seven years (updated to present price level by applying enhancement factor) taking into account the completed as well as works in progress.
   - N = Number of years prescribed for completion of the works for which tenders are invited.
   - B = Value (present price level by applying enhancement factor) of existing commitments and on-going works to be completed during that next N year (period of completion of the works for which the tenders are invited.)

2. In financial criteria, enhancement factor at the rate of 10% per year will be applicable to arrive at enhanced financial amount at current financial year.

ii) Experience Criteria:

The bidder should possess following minimum experience:

a) Bidder shall have experience of having completed (including successful trial run & commissioning) at least one work of similar nature of **60%** of the tendered amount and WTP capacity (**in MLD**) or two works of similar nature of **40%** of the tendered amount and WTP capacity (**in MLD**) or three works

of similar nature of **30%** of the tendered amount and WTP capacity (**in MLD**) in last 7 years from the month of invitation of this tender.

"Work of Similar Nature" means experience of design, detailed engineering, procuring, construction, testing, commissioning of any Water Supply Project **including Water Treatment Plant along with PLC & SCADA System** in any Municipal Body / Urban Local Body / Development Authority / State Government Body or undertaking / any department or undertaking of Government of India and out of these at least one plant shall be in successful operation for minimum one year.

Note: The Bidder who has no experience as well as no specialty in such Water Treatment Plant, as required above, his tender will be rejected out rightly.

b) The bidder should further have experience of successful completion of O&M of minimum one Water Treatment Plant for at least 1 year out of the "Work of Similar Nature" completed by bidder as specified above at a) and considered by bidder for pre-qualification experience criteria.

c) Attested Copy of original certificates in support of above requirements shall be enclosed in hard copy for verification, certified by the respective employer or his authorized representative, not below the rank of an Executive Engineer or equivalent. **Original Certificates of the same shall be produced for verification on demand by employer, failing which, will result in to rejection of tender.**

d) For the purpose of bid evaluation, if the owner/owner's representatives feel necessary to visit a specific or all such plants as mentioned above by the bidder, the bidder shall make necessary arrangements for the same. The cost of such visits shall be borne by the bidder.

e) **Joint Venture will not be permitted for this tender**. However, experience of JV shall be considered for individual JV partner based on the proportionate share of each individual partner in the JV for the purpose of qualification criteria and based on this qualification individual JV partner can bid in the same name and style of individual company forming part of JV. For this purpose, the bidder shall enclosed the notarized copy of JV agreement along with physical submission of technical bid.

f) The experience of Sub-Contractor / back to back works shall not be considered.

3. The bidder should not have been Black Listed by Government of India / Government of Gujarat or any State Board / Corporations, since inception of the firm / Company. A Declaration in this regard on Rs. **300**/- Stamp Paper duly Notarized, shall have to be submitted as per Annexure-II, along with the tender documents.

4. **The bidder should provide accurate information on any litigation history or arbitration resulting from contracts completed or under execution by him over the last ten years.** This should also include such cases, which are in process / progress. In case the bidder has not provided such information and has come to the notice of the authority, the tender will be rejected at what so ever stage and in such case all the losses that will arise out of this issue will be recovered from the tenderer / bidder and he will not have any defense for the same.

5. Reserve the right (i) to change, alter or to waive any technical or commercial terms, condition and qualification (ii) to reject all the bids or any

bid in part or full without assigning any reason whatsoever (iii) for making changes / relaxation in eligibility criteria at any time in the interest of the public. The bidder shall have no cause of action or claim against the Rajkot Municipal Corporation or its Officers / Employee's successor or assignee for rejection of his tender / bid.

6. After opening of Technical Bid, the procedure for the pre-qualification shall be adopted and the Price Bid of only successful qualified bidder shall be opened for final evaluation of the contract. The decision of Municipal Commissioner regarding the pre-qualification shall be final and binding to all the bidders.

7. The Tender of those bidder(s) who fail to submit the required documents physically within the stipulated date and time will be treated as non-responsive and their Price Bid will not be opened.

8. Conditional Tenders will be out rightly rejected.

9. Right to accept / reject any or all e-Tender(s) without assigning any reasons is hereby reserved.

Add. City Engineer
Rajkot Municipal Corporation

1.1 Design Submissions

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

1.1.2 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

1.2.1 All designs shall be based on the latest Indian Standard (I.S.) Specifications or Codes of Practice. The design standards adopted shall follow the best modern engineering practice in the field based on any other international standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by EMPLOYER. In case of any variation or contradiction between the provisions of the I.S. Standards or Codes and the specifications given along with the submitted tender document, the provision given in this Specification shall be followed.

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

I.S. 456	Code of Practice for plain and reinforced concrete
I.S. 875	Code of Practice for design loads for buildings and structures (Part 1 to 5)
I.S. 3370	Code of Practice for concrete structures for the storage of liquids (Part I to IV)
I.S. 1893	Criteria for earthquake resistant design of structures
I.S. 2974	Code of Practice for design and construction of machine foundations (Part 1 to 4)

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

I.S. 800:	Code of Practice for general construction in steel
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 Loading

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, dynamic loads, impact load and other specific loads.

1.4.1 Dead Load

This shall comprise all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipment and other items of machinery.

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 plain 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

1.4.2 Live Load

Live loads shall be in general as per I.S. 875. However, the following minimum loads shall be considered in the design of structures:

(i)	Live load on roofs (accessible)	:	1.50 kN/m^2
	(Non-accessible)	:	0.75 kN/m^2
(ii)	Live load on floors supporting equipment such as pumps, blowers, compressors, 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 I.S. Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of EMPLOYER 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.

1.4.4 Earthquake Load

This shall be computed as per I.S. 1893. An importance factor appropriate to the type of structure shall be considered for design of all the structures. Rajkot is falling under seismic zone-3. However, all the structures shall have to be designed with the criteria of zone-4.

1.4.5 Dynamic Load

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

1.5 Joints

1.5.1 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 all walls and rafts.

~~1.5.2 Expansion joints of suitable gap at suitable intervals not more than 30 m shall be provided in all walls, floors and roof slabs of water retaining structures.~~

1.5.3 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 waterstops of 150 mm width shall be used for walls and 230 mm width for base slabs.

1.5.4 Expansion joints for non liquid retaining structures shall be provided as per IS 3414.

1.5.5 No structural expansion joint is permitted in liquid retaining structure.

1.6 Design Conditions for ESR, Underground or Partly Underground Liquid Retaining Structures.

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

(i) liquid depth to be considered up to full height of wall and no relief due to soil pressure from other side to be considered.

(ii) structure empty condition (i.e., empty of liquid, any material, etc.) **:** full earth pressure with saturation 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 for both the directions.

(v) structures shall be designed for uplift in empty conditions with no live load. Water table is to be considered up to ground level while designing the structure for uplift. Rock anchors shall not be allowed to resist the uplift pressure.

(vi) walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilisation 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.

1.6.2 Design Conditions for Elevated Service Reservoir.

(i) The foundation depth shall be minimum 3 mt or up to hard rock strata whichever is more.

(ii) In case of supporting structure as a shaft, the minimum diameter of the shaft shall be 12 mt. and tolerance limit in the diameter will be ± 0.5%. The thickness of the shaft shall not be less than 250 mm and grade of concrete for shaft and foundation shall be M-30.

(iii) The minimum thickness of components of container will be as under:

a) Bottom dome 200 mm
b) Conical dome 600 mm
c) Cylindrical wall 250 mm
d) Top dome 150 mm

(iv) Depth of water in container maximum 7.6 mt.

1.7 Foundations

(i) The minimum depth of foundations for all structures, equipment, buildings and frame foundations and load bearing walls shall be as per IS 1904.

(ii) Maximum safe bearing capacity of soil strata shall be taken as indicated in geotechnical reports.

(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 EMPLOYER.

(iv) Where there is level difference between the natural ground level & the foundations of structure or floor slabs, this difference shall be filled up in the following ways:

- In case of non-liquid retaining structures the natural top soil shall be removed till a firm strata is reached (minimum depth of soil removed

shall be 500 mm.) and the level difference shall be made up by compacted backfill as per specifications. However the thickness of each layer shall not exceed 150 mm. The area of backfilling for floor slabs shall be confined to prevent soil from slipping out during compaction. The safe bearing capacity of this well compacted backfilled soil shall not exceed 100 kN/sq.m.

- In case of liquid retaining structures, the natural top soil shall be removed as described above and the level difference shall be made up with Plain Cement Concrete (1:5:10)

1.8 Design Requirements

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

a) All blinding and leveling concrete shall be a minimum 100 mm thick in concrete grade CC 1:2:4 for all-structures.
b) All structural reinforced concrete for water retaining structures shall be of a minimum M30 grade with a maximum 20 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all other structural members. For non water retaining structures the concrete shall be of M25 grade. The structures shall have to be designed as per IS : 3370 (Part I-IV).
c) The reinforced concrete for water retaining structures shall have a minimum cement content of 400 kg/m^3 with a maximum 20 mm size aggregate.
d) If limit state design method is adopted, as per IS 3370 – 2009, at serviceability load, maximum stress in reinforcement shall not exceed 0.5 fy (Where fy is characteristic strength of reinforcement)
e) The minimum reinforcement for water retaining structures in each direction should be 0.35% of cross section. The minimum clear cover to all reinforcement including stirrups and links shall be 50 mm for all water retaining structures.
f) All buildings shall have a minimum 1 metre wide, 100 mm thick plinth protection paving in CC 1:2:4 grade concrete or stone slabs/tiles. All plinth protection shall be supported on well compacted strata.
g) Any structure or pipeline crossing below roads shall be designed for Class A of IRC loading.
h) The bridges & bridge supporting structures shall be designed to safely withstand the loading.
i) All pipes & conduits laid below the structural plinth & road works shall be embedded in reinforced concrete of grade CC 1:2:4 of minimum thickness 150 mm.
j) Approved quality water proofing compound (chloride free) shall be added during concreting of all liquid containing structure in the proportions specified by manufacturer or 2 % by weight of cement whichever is higher.
k) The wall and floor panels shall be poured in sequential order with a minimum time gap of 4 days.

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

(i)	Walls for liquid retaining structures	:	250 mm
(ii)	Channel / Launder	:	150mm

(iii)	Roof slabs for liquid retaining structures (other than flat slabs)	:	150 mm
(iii)	Bottom slabs for liquid retaining structures	:	200 mm
(iv)	Floor slabs including roof slabs, walkways, canopy slabs	:	125 mm
(v)	Walls of cables / pipe trenches, underground pits etc.	:	125 mm
(vi)	Column footings	:	300 mm
(vii)	Parapets, chajja	:	100 mm
(viii)	Precast trench cover	:	100 mm

- In Mix design, the water cement ratio should not exceed 0.45. The exposure condition to be considered as severe.

1.9 Materials in General

1.9.1 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.

1.9.2 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.

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

1.9.4 As soon as practicable after receiving the order to commence the Works, the Contractor shall inform EMPLOYER 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 EMPLOYER which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep EMPLOYER informed of orders for and delivery dates of all materials.

1.9.5 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

1.10.1 The Contractor shall submit samples of such materials as may be required by EMPLOYER and shall carry out the specified tests directed by EMPLOYER at the Site, at the supplier's premises or at a laboratory approved by EMPLOYER. EMPLOYER may appoint separate third party inspection for the material testing to ensure the quality of the work. The Contractor shall replace the defective material as an outcome of these tests.

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

1.10.3 The Contractor shall give EMPLOYER 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 EMPLOYER. Representative of EMPLOYER 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 EMPLOYER to carry out such a test on a mutually agreed date in his presence. The Contractor shall in any case submit to EMPLOYER's Representative within seven days of every test such number of certified copies (minimum six) of the test results as EMPLOYER may require.

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

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

1.10.6 If need arise, non-destructive of the structural components shall be carried out by the agency as per directions of engineer-in-charge of client at his own cost.

1.11 Standards

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

1.11.2 Where the relevant standard provides for the furnishing of a certificate to EMPLOYER, 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 EMPLOYER.

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

1.11.4 In case of discrepancy between the Bid Specification and the Standards referred to herein, the Bid 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 : 777	Specification for glazed earthenware tiles
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 paneled 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 roofing
IS : 3502	Specification for steel chequerred 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 44)
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 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)

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
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 aluminum) 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 : 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 (Parts1 & 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 1-4)
IS : 13920	Code of practice for laying of glazed stoneware pipes
IS: 4326	Code of practice for Earthquake Resistant Design and Construction of Buildings
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 Orientation

1.12.1 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 pipework . Underground services requiring to be relocated in order to accommodate the proposed site layout shall, with the approval of EMPLOYER, be relocated by the Contractor.

1.13 Buildings and Structures

1.13.1 All the building and structure works shall generally comply with the following EMPLOYER's requirements unless otherwise specified elsewhere.

1. All building works shall be of reinforced concrete framework.

2. All external walls shall be in 230 mm thick brick masonry built cement mortar in 1:4. Transoms and mullions of 115 mm x 230 mm size with four numbers 6 mm bars and 6 mm links at 150 mm c/c shall be provided to form panels not exceeding 3500 mm x 3500 mm in size.

3. All internal partition walls except for toilets and Residential units shall be in 230 mm thick brick masonry built in cement mortar 1:4 with transoms and mullions as in (2) above. Toilet partition walls shall be in 115 mm thick brick

masonry built in cement mortar 1:4 and shall have transoms and mullions as in (2) above and shall form panels not exceeding 1200 mm x 1200 mm in size.

(a) Finishes to concrete liquid retaining structures (for details, refer clause 3.16 of this volume) 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 (for details, refer clause 3.16 of this volume) shall be :

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

4. All internal masonry surfaces finish shall have 15 mm thick plain faced cement plaster in cement mortar (1:4) with neat lime or neeru finish on top. Over this, one coat of primer and two coats of plastic emulsion paint of approved quality and shade shall be provided.

5. All external masonry surfaces shall have 20 mm thick sand faced cement plaster in cement mortar (1:3) in two coats. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.

6. 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.

7. Toilet areas, walls and ceilings, shall have one coat of primer and two coats of plastic emulsion paint.

8. 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.

9. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.

10. The flooring in all areas except toilets and staircases shall be in 250 mm x 250 mm x 20 mm thick white cement based marble mosaic tiles or vitrified tiles of approved shade and pattern and placed in cement mortar or lime mortar to give overall thickness of 50 mm. Half tile skirting shall also be provided in these areas.

11. Toilet areas shall have 450 mm x 450 mm x 25 mm thick polished marble Kota stone tiles placed in cement mortar or lime mortar to give an overall thickness of 50 mm. 2200 mm high ceramic tile (size 200 mm x 200 mm x 6 mm thick) dado placed in cement mortar shall also be provided in these areas. In W.C. areas, the flooring and 2200 mm high dado shall be provided with 200 mm x 200 mm x 6 mm thick coloured ceramic tiles.

12. All staircases shall have 25 mm thick chequered mosaic tiles for treads and 25 mm thick plain mosaic tiles of approved shade for risers set in cement mortar or lime mortar to give an overall thickness of 50 mm.

Stairways shall be provided to permit access between different levels within buildings. All roof tops and overhead tanks shall be made accessible with ladder provision. Vertical ladders fitted with landing point extensions will be permitted where considered appropriate by the EMPLOYER to access areas not frequently visited.

13 All floor cut-outs and cable ducts, etc. shall be covered with precast concrete covers in outdoor areas and mild steel chequered plates of adequate thickness in indoor areas. All uncovered openings shall be protected with M.S. hand railing of 32 NB (M).

14. All staircases shall be provided with 32 NB (M) galvanised M.S. pipe hand railing for protection.

15. The reinforced concrete roofs shall be made waterproof by application of an approved roof polythene / bitumen membrane. The finished roof surface shall have adequate slope to drain quickly the rain water to R.W downtake inlet points.

16. For roofing drainage, cast iron/PVC rainwater downtakes with bell mouth and C.I. grating at top shall be provided. For roof areas up to 100 sq.m minimum two nos. 100 mm diameter downtake pipes shall be provided. For every additional area of 100 sq.m or part thereof, at least one no. 100 mm dia. downtake pipe shall be provided.

17. 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. Chajjas, canopies and roof projections shall have drip moulds.

18. Building plinth shall be minimum 600 mm above average finished ground level around building.

19. 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.

20. All windows and ventilators shall have 25 mm thick marble stone sills bedded in cement mortar (1:3)

21. 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 handrailings.

22. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of Factory Act.

23. All rooms in the buildings shall be provided with appropriate sign boards indicating the function of the rooms involved.

24. Wherever equipment and machinery are to be moved for inspection, servicing, replacement etc., suitable movable gantry in the form of EOT / HOT crane shall be provided. Minimum capacity of 2 tonnes or more as required shall be provided for monorail.

25. The design of buildings shall be suitable for the climatic conditions existing on site. Buildings shall as far as is possible permit the entry of natural light.

26. Emergency exit doorways with Signboards shall be provided from all buildings in order to comply with local and international regulations. Stairways and paved areas shall be provided at the exit points.

27. The side walls of buildings shall, comprise at least 15% ventilated brickwork or louvers. Ventilated brickwork or louvers shall not be used where the ingress of driven rain could affect equipment or stored materials.

1.14 Roadways, & Pathways

1.14.1 A comprehensive network of roadways shall be provided around the structures to link in with the existing road network and permit access to the units for necessary maintenance, delivery of consumables and personnel access. All roads shall be of asphalt macadam / CC Pavement and minimum 5 metres wide with 1.5 m wide paved shoulders on both side. 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.

1.15 Site Drainage

The contractor shall provide a site drainage system which shall comprise of the Storm Water Drainage and Foul Drainage.

1.15.1 Storm Water Drainage

Storm water drains adjacent to the existing and proposed roads (under this Contract) shall be sized for a rainfall intensity of 80 mm/hr, allowing for 100% runoff. Drains

adjacent to roads shall be in RCC (M25) of appropriate thickness, topped with M25 precast concrete covers and plastered internally in cement mortar (1:4), 20 mm thick.

The storm water drainage system shall be designed to cater for the run-off from the structures, if necessary.

1.15.2 Foul Drainage

The foul drainage system shall accept discharge from toilets, washrooms, offices and shall discharge to separate septic tank and further to a soak pit, both of appropriate volumes for individual buildings.

1.16 Cable and Pipework Trenches

1.16.1 Cable and pipework 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 350 mm thick brick masonry (1:4). The trenches will be plastered internally with cement mortar (1:4) and externally in cement mortar (1:3).

1.16.2 Trenches within the buildings or Plant areas shall be covered with M.S chequered plates, suitably painted and those outside the buildings shall be covered with M20 precast R.C.C covers. The trenches shall be suitably sloped to drain rain water.

1.16.3 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 EMPLOYER while planning the works.

1.17 Pipes and Ducts

1.17.1 R.C.C ducts for drainage shall have minimum 1 metre cover while laid under roads. Access shafts of size not less than 600 mm x 1000 mm shall be provided.

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

1.18 Valve Chambers

All valve chambers are to be of an adequate size to facilitate maintenance and operation. The base slab of valve chambers shall slope towards a sump pit from which water can be pumped to keep the chamber dry. All valve chambers shall be constructed in M20 grade reinforced concrete / 8mm thk MS Plate cover. Chambers shall have removable reinforced concrete covers, as appropriate, approach ladders and valve supports.

1.19 Landscaping

1.19.1 The WTP plot site shall be landscaped once the Works are substantially complete. The landscaping scheme shall be submitted and got approved from EMPLOYER prior to start of actual work.

1.19.2 Landscaping shall include planting of suitable trees and development of 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. Medicinal and fruit trees shall be avoided.

1.19.3 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 shall be provided.

1.20 Security Fencing and Gates

1.20.1 Compound wall for the WTP plot shall have to be provided as shown in the tender drawing.

1.20.2 Substation shall have internal fencing as per Electricity Board guidelines.

1.20.3 4.5m wide x 2.2m high main steel gates and 1m wide x 2.2 m high steel wicket gate made out of tubular sections/square bars/flats of welded construction alongwith the locking arrangement and posts to match with security fencing shall be provided at appropriate places. Gates shall be painted with similar synthetic enamel paint.

1.20.4 Chain link fencing with gates around electrical installations shall be provided as per Power Supply Company's requirements.

2.0 EARTHWORKS

2.1 Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

a) IS 783 - 1985 - Code of practice for laying of concrete pipes.
b) IS 3764 - 1992 - Excavation work - Code of Safety .
c) IS 2720 - Methods of test for soils:

(Part-1) - 1983	-	Part 1 Preparation of dry soil samples for various tests.
(Part-2) - 1986	-	Part 2 Determination of Water Content.
(Part-4) - 1985	-	Part 4 Grain size analysis.
(Part-5) - 1985	-	Part 5 Determination of liquid and plastic limit.
(Part-7) - 1980	-	Part 7 Determination of water content - dry density relation using light compaction.
(Part-9) - 1971	-	Part 9 Determination of dry density - moisture content by constant weight of soil method.
(Part-14) – 1983	-	Part 14 Determination of density index (relative density) of cohesionless soils.
(Part-22) – 1978	-	Part 22 Determination of organic matter.
(Part-26) – 1987	-	Part 26 Determination of pH Value.
(Part-27) – 1987	-	Part 27 Determination of total soluble sulphates.
(Part-28) – 1974	-	Part 28 Determination of dry density of soils in place, by the sand replacement method.
(Part-33) – 1971	-	Part 33 Determination of the density in place by the ring and water replacement method.
(Part-34) – 1972	-	Part 34 Determination of density of soil in place by rubber balloon method.

(Part-38) – 1976 - Part 38 Compaction control test (Hilf Method)

2.2 General

2.2.1 The Contractor shall furnish all tools, plant, instruments, qualified supervisory personnel, labour, materials, any temporary works, consumables, any and everything necessary, whether or not such items are specifically stated herein for completion of the work in accordance with the Employer's Requirements.

2.2.2 The Contractor shall survey the site before excavation and set out all lines and establish levels for various works such as grading, basement, foundations, plinth filling, roads, drains, cable trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to established reference/grid lines at 8m intervals or nearer, if necessary, based on ground profile and thereafter properly recorded.

2.2.3 The excavation shall be carried out to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades around excavated areas and warning lamps at night.

2.2.4 Excavated material shall be dumped in regular heaps, bunds, riprap with regular slopes within the lead specified and levelling the same so as to provide natural drainage. Rock/soil excavated shall be stacked properly as approved by the Employer's Representative. As a rule, all softer material shall be laid along the center of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.

2.2.5 Topsoil shall be stock piled separately for later re-use.

2.3 Clearing the site

2.3.1 The area to be excavated/filled shall be cleared of fences, trees, plants, logs, stumps, bush, vegetation, rubbish, slush, etc. and other objectionable matter. If any roots or stumps of trees are encountered during excavation, they shall also be removed. The material so removed shall be disposed off as approved by the Employer's Representative. Where earthfill is intended, the area shall be stripped of all loose/ soft patches, top soil containing objectionable matter/ materials before fill commences.

2.4 Excavation

2.4.1 All excavation work shall be carried out by mechanical equipment unless, in the opinion of Employer's Representative, the work involved requires it to be carried out by manual methods.

2.4.2 Excavation for permanent work shall be taken out to such widths, lengths, depths and profiles as are shown on the drawings provided by the Contractor or such other lines and grades as may be agreed with the Employer's Representative. Rough excavation shall be carried out to a depth of 150mm above the final level. The balance shall be

excavated with special care. Soft pockets shall be removed below the final level and extra excavation filled up with lean concrete as approved by the Employer's Representative. The final excavation should be carried out just prior to laying the blinding course.

2.4.3 To facilitate the permanent works the Contractor may excavate, and also backfill later, outside the lines shown on the drawings provided by the Contractor as agreed with the Employer's Representative. Should any excavation be taken below the specified elevations, the Contractor shall fill it up with concrete of the same class as in the foundation resting thereon, upto the required elevation at no cost to the Employer.

2.4.4 All excavations shall be to the minimum dimensions required for safety and ease of working. Prior approval of the Employer's Representative shall be obtained by the Contractor in each individual case, for the method proposed for the excavation, including dimensions, side slopes, dewatering, disposal, etc. This approval, shall not in any way relieve the Contractor of his responsibility for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. Side slopes shall be as steep as will stand safely for the actual soil conditions encountered. Every precaution shall be taken to prevent slips. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope.

2.4.5 This work shall consist of removing, as hereinafter set fouth, existing buildings,roofs,ceiling,flooring and paving, concrete and brick work, partitions, wood work, steel and iron work, doors and windows, pipes and sewer lines, posts or struts,fencing wire mesh, glazing, culverts, bridges, pavements, kerbs and other structures like guard-raills, utility services, catch basins, inlets,etc., which are in place but interfere with the new construction or are not suitable to remain in place, and of salvaging and disposing of the resulting materials and back filling the resulting trenches and pits.

2.4.6 Unless otherwise directed on the project specifications, all the following items are included in the excavation:

1. Removing all surface obstructions including shrubs,jungle etc.
2. Making all necessary excavations true to line and grade,
3. Furnishing and installing all shoring and bracing as necessary or as directed
4. Pumping and bailing out water to keep trenches free of water during pipe laying and jointing and thereafter until joints mature,
5. Providing for uninterrupted surface water flow during work in progress,
6. Providing for disposing off water flows from strom, drains, nallas or other sources, suitably,
7. Protecting all pipes, conduits, culverts, railway tracks, utility poles, wire fences,buildings, and other public and private property adjacent to or in the line of work,
8. Removing all shoring and bracing which is not ordered to be left in place or not required by the project plans or specifications to remain in place,
9. Hauling away and disposing of excavated materials not necessary or else unsuitable for back filling purpose. The extra excavated soil will have to be properly as directed,

10. Backfilling the trenches as directed or as per specifications,
11. Restoring all property injured or disturbed by these construction activities to the condition as near its original condition as possible,
12. Restoring the surface and repairing of all roads, streets, alleys,walks, drives, working spaces, and rights of way to a condition as good as prior to excavation.

2.4.7 Slipes and Slides

If slips,slides,over-breaks or subsidence occur in cutting during the process of construcyion, they shall be removed at the cost of the contractor as ordered by the Engineer.Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope.

2.5 Rock

2.5.1 General

'Rock' means a natural aggregate of mineral crystals which for its excavation would normally require the use of heavy pneumatic/hydraulic breaker and/or cutting equipment or explosives. the term shall exclude any material that can be removed by ordinary excavating machinery and which in any individual mass has a volume not exceeding $1m^3$ or $0.25m^3$ where the net width of excavation is less than 2 m. Ordinary excavating machinery means a hydraulic back hoe with rated output of 50 KW or less.

2.5.2 Before classification of material as rock the Contractor shall demonstrate to the satisfaction of the Employer's Representative his inability to excavate it without resort to heavy percussion tools complete with rock bits, hydraulic wedges or blasting. Excavation by the use of explosive will not normally be permitted except for pipeline.

2.5.3 Material shall not be classified as rock unless the Employer's Representative has agreed to such classification on the basis of such a demonstration before its excavation. Excavations where rock has been encountered and classified as such shall not be backfilled before examination of the excavated faces by the Employer's Representative to enable the extent of the rock excavation to be determined.

2.5.4 Excavation by the Use of Explosives

Unless otherwise stated herein, I.S. Specification " IS:4081: Safety Code for Blasting and related Drilling Operations" shall be followed. As far as possible all blasting shall be completed prior to commencement of construction. At all stages of excavation, precautions shall be taken to preserve the rock below and beyond the lines specified for the excavation, in the soundest possible condition. The quantity and strength of explosives used, shall be such as will neither damage nor crack the rock outside the limits of excavation. All precautions, as directed by Employer's Representative, shall be taken during the blasting operations and care shall be taken that no damage is caused to adjoining buildings or structures as a result of blasting operations. In case of damage to permanent or temporary structures, Contractor shall repair the same to the satisfaction of Employer's Representative at his cost. As excavation approaches its final lines and levels, the depth of the charge holes and amount of explosives used shall be progressively and suitably reduced.

2.5.5 The contractor shall obtain a valid Blasting License from the authorities concerned. No explosive shall be brought near the work in excess of quantity required for a particular amount of firing to be done; and surplus left after filling the holes shall be removed to the magazine. The magazine shall be built as away as possible from the area to be blasted. Employer's Representative's prior approval shall be taken for the location proposed for the magazine.

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

2.5.7 For blasting operations, the following points shall be observed.

i) Contractor shall employ a competent and experienced supervisor and licensed blaster in-charge of each set of operation, who shall be held personally responsible to ensure that all safety regulations are carried out.

ii) Before any blasting is carried out, Contractor shall intimate Employer's Representative and obtain his approval in writing for resorting to such operations. He shall intimate the hours of firing charges, the nature of explosive to be used and the precautions taken for ensuring safety.

iii) Contractor shall ensure that all workmen and the personnel at site are excluded from an area within 200 m radius from the firing point, at least 15 minutes before firing time by sounding warning whistle. The area shall also be given a warning by sounding a distinguishing whistle.

iv) The blasting of rock near any existing buildings, equipments or any other property shall be done under cover and Contractor has to make all such necessary muffling arrangements. Covering may preferably be done by MS plates with adequate dead weight over them. Blasting shall be done with small charges only and where directed by Employer's Representative, a trench shall have to be cut by chiseling prior to the blasting operation, separating the area under blasting from the existing structures.

v) The firing shall be supervised by a Supervisor and not more than 6 (six) holes at a time shall be set off successively. If the blasts do not tally with the number fired, the misfired holes shall be carefully located after half an hour and when located, shall be exploded by drilling a fresh hole along the misfired hole (but not nearer than 600 mm from it) and by exploding a new charge.

vi) A wooden tamping rod with a flat end shall be used to push cartridges home and metal rod or hammer shall not be permitted. The charges shall be placed firmly into place and not rammed or pounded. After a hole is filled to the required depth, the balance of the hole shall be filled with stemming which may consist of sand or stone dust or similar inert material.

vii) Contractor shall preferably detonate the explosives electrically.

viii) The explosives shall be exploded by means of a primer which shall be fired by detonating a fuse instantaneous detonator (F.I.D) or other approved cables. The detonators with F.I.D. shall be connected by special nippers.

ix) In dry weather and normal dry excavation, ordinary low explosive gunpowder may be used. In damp rock, high explosive like gelatin with detonator and fuse wire may be used. Underwater or for excavation in rock with substantial accumulated seepage electric detonation shall be used.

x) Holes for charging explosives shall be drilled with pneumatic drills, the drilling pattern being so planned that rock pieces after blasting will be suitable for handling without secondary blasting.

xi) When excavation has almost reached the desired level, hand trimming shall have to be done for dressing the surface to the desired level. Any rock excavation beyond an overbreak limit of 75 mm shall be filled up as instructed by Employer's Representative, with concrete of strength not less than M10. Stopping in rock excavation shall be done by hand trimming.

xii) Contractor shall be responsible for any accident to workmen, public or Employer's property due to blasting operations. Contractor shall also be responsible for strict observance of rules, laid by Inspector of explosives, or any other Authority duly constituted under the State and / or Union Government as applicable at the place of excavation.

2.6 Stripping Loose Rock

2.6.1 All loose boulders, detached rocks partially and other loose material which might move therewith not directly in the excavation but so close to the area to be excavated as to be liable, in the opinion of Employer's Representative, to fall or otherwise endanger the workmen, equipment, or the work shall be stripped off and removed from the area of the excavation. The method used shall be such as not to render unstable or unsafe the portion which was originally sound and safe.

2.6.2 Any material not requiring removal in order to complete the permanent works, but which, in the opinion of Employer's Representative, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed.

2.7 Fill, Backfilling and Site Grading

2.7.1 General

All fill material shall be subject to the Employer's Representative's approval. If any material is rejected by Employer's Representative, the Contractor shall remove the same forthwith from the site. Surplus fill material shall be deposited/disposed off as directed by Employer's Representative after the fill work is completed.

2.7.2 No earthfill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with to the approval of the Employer's Representative.

2.7.3 Material

To the extent available, selected surplus soil from excavations shall be used as backfill. Backfill material shall be free from lumps, organic or other foreign material. All lumps of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of murum or earth to fill the voids and the mixture used for filling.

2.7.4 If fill material is required to be imported, the Contractor shall make arrangements to bring such material from outside borrow pits. The material and source shall be subject to the prior approval of the Employer's Representative. The approved borrow pit areas shall be cleared of all bushes, roots of trees, plants, rubbish, etc. Top soil containing foreign material shall be removed. The materials so removed shall be disposed of as directed by Employer's Representative. The Contractor shall provide the necessary access roads to borrow areas and maintain the same if such roads do not exist.

2.7.5 Filling in pits and trenches around foundations of structures, walls, etc.

As soon as the work in foundations has been accepted and measured, the spaces around the foundations, structures, pits, trenches, etc., shall be cleared of all debris, and filled with earth in layers not exceeding 15 cm, each layer being watered, rammed and properly consolidated, before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of Employer's Representative. Earth shall be rammed with approved mechanical compaction machines. Usually no manual compaction shall be allowed unless the Employer's Representative is satisfied that in some cases manual compaction by tampers cannot be avoided. The final backfill surface shall be trimmed and leveled to a proper profile to the approval of the Employer's Representative.

2.7.6 Plinth Filling

Plinth filling shall be carried out with approved material as described hereinbefore in layers not exceeding 15cm, watered and compacted with mechanical compaction machines. The Employer's Representative may, however, permit manual compaction by hand tampers where he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlement at a later stage. The finished level of the filling shall be trimmed to the level/slope specified.

2.7.7 Compaction of the plinth fill shall be carried out by means of 12 ton rollers smooth wheeled, sheep-foot or wobbly wheeled rollers. In case of compaction of granular material such as sands and gravel, vibratory rollers shall be used. A smaller weight roller may be used only if permitted by the Employer's Representative. As rolling proceeds, water sprinkling shall be done to assist consolidation. Water shall not be sprinkled in case of sandy fills.

2.7.8 The thickness of each unconsolidated fill layer can in this case be upto a maximum of 300mm. The Contractor will determine the thickness of the layers in which fill has to be consolidated depending on the fill material and equipment used and the approval of the Employer's Representative obtained prior to commencing filling.

2.7.9 Rolling shall commence from the outer edge and progress towards the centre and continue until compaction is to the satisfaction of Employer's Representative, but in no case less than 10 passes of the roller will be accepted for each layer.

2.7.10 The compacted surface shall be properly shaped, trimmed and consolidated to an even and uniform gradient. All soft spots shall be excavated, then filled and consolidated.

2.7.11 At some locations/areas, it may not be possible to use rollers because of space restrictions, etc. The Contractor shall then be permitted to use pneumatic tampers, rammers, etc. and he shall ensure proper compaction.

2.7.12 Sand Filling in Plinth and Other Places

Where backfilling is required to be carried out with local sand it shall be clean, medium grained and free from impurities. The filled-in-sand shall be kept flooded with water for 24 hours to ensure maximum consolidation. The surface of the consolidated sand shall be dressed to required level or slope. Construction of floors or other structures on sand fill shall not be started until the Employer's Representative has inspected and approved the fill.

2.7.13 Filling in Trenches

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

2.7.14 Where the trenches are excavated in soil, the filling from the bottom of the trench to the level of the centre line of the pipe shall be done by hand compaction with selected approved earth in layers not exceeding 8 cm; backfilling above the level of the centre line of the pipes shall be done with selected earth by hand compaction, or other approved means in layers not exceeding 15 cm.

2.7.15 In case of excavation of trenches in rock, the filling upto a level 30 cm above the top of the pipe shall be done with fine materials such as earth, murum, etc. The filling up to the level of the centre line of the pipe shall be done by hand compaction in layers not exceeding 8 cm whereas the filling above the centre line of the pipe shall be done by hand compaction or approved means in layers not exceeding 15 cm. The filling from a level 30 cm above the top of the pipe to the top of the trench shall be done by hand or other approved mechanical methods with broken rock filling of size not exceeding 15 cm mixed with fine material as available to fill up the voids.

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

2.8 General Site Grading

2.8.1 Site grading shall be carried out as indicated in the drawings and as approved by the Employer's Representative. Excavation shall be carried out as specified in the Employer's Requirements. Filling and compaction shall be carried out as specified under Clause 2.7 and elsewhere unless otherwise indicated below.

2.8.2 If no compaction is called for, the fill may be deposited to the full height in one operation and levelled. If the fill has to be compacted, it shall be placed in layers not exceeding 225 mm and levelled uniformly and compacted as indicated in Clause 2.7 before the next layer is deposited.

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

2.8.4 Field compaction tests shall be carried out in each layer of filling until the fill to the entire height has been completed. This shall hold good for embankments as well. The fill will be considered as incomplete if the desired compaction has not been obtained.

2.8.5 The Contractor shall protect the earth fill from being washed away by rain or damaged in any other way. Should any slip occur, the Contractor shall remove the affected material and make good the slip.

2.8.6 If so specified, the rock as obtained from excavation may be used for filling and levelling to indicated grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cms approximately. After rock filling to the approximate level, indicated above has been carried out, the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and consolidation carried out by a 12 ton roller. No less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

2.9 Fill Density

2.9.1 The compaction, under the plant road area and building plinths shall comply with minimum 95% compaction by Standard Proctor at moisture content differing not more than 4% from the optimum moisture content. The Contractor shall demonstrate adequately by field and laboratory tests that the specified density has been obtained. In other areas the soil should be backfilled and compacted suitably as specified by the Engineer.

2.10 Timber Shoring

2.10.1 Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. These shall be of minimum 25 cm x 4 cm sections or as approved by the Employer’s Representative. The boards shall generally be placed in position vertically side by side without any gap on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2 metre spacings, strutted with ballies or as approved by the Employer’s Representative. The length of the ballie struts shall depend on the width of the trench or pit. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported by vertical walling, which in turn shall be suitably strutted. The lowest boards supporting the sides shall be taken into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

2.10.2 Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as approved by the Employer’s Representative. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of excavations, trenches, pits, etc. from collapsing.

2.10.3 Timber shoring may also be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only under instructions from the Employer's Representative.

2.10.4 The withdrawal of the timber shall be done carefully to prevent the collapse of the pit or trench. It shall be started at one end and proceeded with, systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber.

2.10.5 In the case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25 cm x 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangement, sizes of the timber and the spacings shall be subject to the approval of the Employer's Representative. In all other respects, the Employer's Requirements for close timbering shall apply to open timbering.

2.10.6 In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures or for any other reasons and where the planking across sides of excavations/pits cannot be strutted against, suitable inclined struts supported on the excavated bed shall be provided. The load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut.

2.11 Dewatering

2.11.1 The Contractor shall ensure that the excavation and the structures are free from water during construction and shall take all necessary precautions and measures to exclude ground/rain water so as to enable the works to be carried out in reasonably dry conditions in accordance with the construction programme. Sumps made for dewatering must be kept clear of the excavations/trenches required for further work. The method of pumping shall be approved by Employer's Representative, but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction. The dewatering shall be continued for at least (7) seven days after the last pour of the concrete. The Contractor shall, however, ensure that no damage to the structure results on stopping of dewatering.

2.11.2 The Contractor shall study the sub-soil conditions carefully and shall conduct any tests necessary at the site with the approval of the Employer's Representative to test the permeability and drainage conditions of the sub-soil for excavation, concreting etc., below ground level.

2.11.3 The scheme for dewatering and disposal of water shall be approved by the Employer's Representative. The Contractor shall suitably divert the water obtained from dewatering from such areas of site where a build up of water in the opinion of the Employer's Representative obstructs the progress of the work, leads to insanitary conditions by stagnation, retards the speed of construction and is detrimental to the safety of men, materials, structures and equipment.

2.11.4 When there is a continuous inflow of water and the quantum of water to be handled is considered in the opinion of Employer's Representative, to be large, a well point system- single stage or multistage, shall be adopted. The Contractor shall submit to the Employer's Representative, details of his well point system including the stages, the spacing, number and diameter of well points, headers etc., and the number, capacity and location of pumps for approval.

2.12 Rain Water Drainage

2.12.1 Grading in the vicinity of excavation shall be such as to exclude rain/ surface water draining into excavated areas. Excavation shall be kept clean of rain and such water as the Contractor may be using for his work by suitably pumping out the same. The scheme for pumping and discharge of such water shall be approved by the Employer's Representative.

3.0 CONCRETE WORKS

3.1 Applicable Codes

3.1.1 Materials

1) IS.269 Specification for 33 grade ordinary portland cement.

2) IS.455 Specification for portland slag cement.

3) IS.1489 Specification for portland-pozzolana cement (Part 1&2).

4) IS:8112 Specification for 43 grade ordinary portland cement.

5) IS:12269 Specification for 53 grade ordinary portland cement.

6) IS:12330 Specification for sulphate resisting portland cement.

7) IS:383 Specification for coarse and fine aggregates from natural sources for concrete.

8) IS:432 Specification for mild steel and medium (tensile steel bars and hard-drawn steel) wires for concrete reinforcement. (Part 1 and 2)

9) IS:1786 Specification for high strength deformed steel bars and wires for concrete reinforcement.

10) IS:1566 Specification for hard-drawn steel wire fabric for concrete reinforcement.

11) IS:9103 Specification for admixtures for concrete.

12) IS:2645 Specification for integral cement water- proofing compounds.

13) IS:4990 Specification for plywood for concrete shuttering work.

3.1.2 Material Testing

1) IS.4031 Methods of physical tests for hydraulic cement (Parts 1 to 15)

2) IS:4032 Method chemical analysis of hydraulic cement.

3) IS:650 Specification for standard sand for testing of cement.

4) IS:2430 Methods for sampling of aggregates for concrete.

5) IS.2386 Methods of test for aggregates for concrete (Parts 1 to 8)

6) IS:3025 Methods of sampling and test (physical and chemical) for water

used in industry.

7) IS:6925 Methods of test for determination of water soluble chlorides in concrete admixtures.

3.1.3 Material Storage

1) IS:4082 Recommendations on stacking and storing of construction materials at site.

3.1.4 Concrete Mix Design

1) IS:10262 Recommended guidelines for concrete mix design.

2) SP:23 (S&T) Handbook on Concrete Mixes

3.1.5 Concrete Testing

1) IS.1199 Method of sampling and analysis of concrete.

2) IS:516 Method of test for strength of concrete.

3) IS:9013 Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.

4) IS:8142 Method of test for determining setting time of concrete by penetration resistance.

5) IS:9284 Method of test for abrasion resistance of concrete.

6) IS:2770 Methods of testing bond in reinforced concrete.

3.1.6 Equipments

1) IS:1791 Specification for batch type concrete mixers.

2) IS:2438 Specification for roller pan mixer.

3) IS:4925 Specification for concrete batching and mixing plant.

4) IS:5892 Specification for concrete transit mixer and agitator.

5) IS:7242 Specification for concrete spreaders.

6) IS:2505 General Requirements for concrete vibrators: Immersion type.

7) IS:2506 General Requirements for screed board concrete vibrators.
8) IS:2514 Specification for concrete vibrating tables.

9) IS:3366 Specification for pan vibrators.

10) IS:4656 Specification for form vibrators for concrete.

11) IS:11993 Code of practice for use of screed board concrete vibrators.

12) IS:7251 Specification for concrete finishers.

13) IS:2722 Specification for portable swing weigh batchers for concrete (single and double bucket type).

14) IS:2750 Specification for steel scaffoldings.

3.1.7 Codes Of Practice

1) IS:456 Code of practice for plain and reinforced concrete.

2) IS:457 Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.

3) IS:3370 Code of practice for concrete structures for storage of liquids (Parts 1 to 4)

4) IS:3935 Code of practice for composite construction.

5) IS:2204 Code of practice for construction of reinforced concrete shell roof.

6) IS:2210 Criteria for the design of reinforced concrete shell structures and folded plates.

7) IS:2502 Code of practice for bending and fixing of bars for concrete reinforcement.

8) IS:5525 Recommendation for detailing of reinforcement in reinforced concrete works.

9) IS:2751 Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.

10) IS:9417 Specification for welding cold worked bars for reinforced concrete construction.

11) IS:3558 Code of practice for use of immersion vibrators for consolidating concrete.

12) IS:3414 Code of practice for design and installation of joints in buildings.

13) IS:4326 Code of practice for earthquake resistant design and construction of building.

14) IS:4014 Code of practice for steel tubular scaffolding (Parts 1 & 2)

15) IS:2571 Code of practice for laying insitu cement concrete flooring.

16) IS:7861 Code of practice for extreme weather concreting : Part 1 Recommended practice for hot weather concreting.

3.1.8 Construction Safety

1) IS.3696 Safety code for scaffolds and ladders. (Parts 1 & 2)
2) IS:7969 Safety code for handling and storage of building materials.
3) IS:8989 Safety code for erection of concrete framed structures.

3.2 General

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

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

3.3 Materials

3.3.1 Cement

Cement shall be ordinary portland cement conforming to IS:269, IS:8112 or IS:12269 for all structures.

3.3.2 Where Portland pozzolana or slag cements are used, it shall be ensured that consistency of quality is maintained, there will be no adverse interactions between the materials and the finish specified is not marred.

3.3.3 Only one type of cement shall be used in any one mix. The source of supply, type or brand of cement within the same structure or portion thereof shall not be changed without approval from the EMPLOYER.

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

3.3.5 Aggregates (General)

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

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

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

3.3.8 The fineness modulus of sand shall neither be less than 2.2 nor more than 3.2.

3.3.9 The maximum size of coarse aggregate shall be as stated on the drawings but in no case greater than 1/4 of the minimum thickness of the member.

3.3.10 Plums 160 mm and above of a reasonable size may be used in mass concrete fill where directed. Plums shall not constitute more than 20% by volume of the concrete.

3.3.11 Water

Water used for both mixing and curing shall conform to IS:456. Potable waters are generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used.

3.3.12 Reinforcement

All reinforcement steel shall be of TMT Fe-500 grade and welded wire fabric to IS:1566 as shown or specified on the drawing.

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

3.3.13 Admixtures

3.3.13.1 Accelerating, retarding, water-reducing and air entraining admixtures shall conform to IS:9103 and integral water proofing admixtures to IS:2645.

3.3.13.2 Admixtures may be used in concrete as per manufacturer's instructions only with the approval of the EMPLOYER. An admixture's suitability and effectiveness shall be verified by trial mixes with the other materials used in the works. If two or more admixtures are to be used simultaneously in the same concrete mix, their interaction shall be checked and trial mixes done to ensure their compatibility. There should also be no increase in risk of corrosion of the reinforcement or other embedments.

3.3.13.3 Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted such as in mass concrete works, it shall be dissolved in water and added to the mixing water by an amount not exceeding 1.5 percent of the weight of the cement in each batch of concrete. The designed concrete mix shall be corrected accordingly.

3.3.14 Wastage

Wastage allowance for cement and steel shall not be considered and no extra payment shall become payable to the Contractor on any account.

3.4 Samples and Tests

3.4.1 All materials used for the works shall be tested before use.

3.4.2 Manufacturer's test certificate shall be furnished for each batch of cement/steel and when directed by the EMPLOYER samples shall also be got tested by the Contractor in a laboratory approved by the EMPLOYER at no extra cost to Employer. EMPLOYER may appoint separate third party inspection for the material testing to ensure the quality of the work. The Contractor shall replace the defective material as an outcome of these tests.

3.4.3 Sampling and testing shall be as per IS:2386 under the supervision of the EMPLOYER.

3.4.4 Water to be used shall be tested to comply with requirements of IS:456.

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

3.5 Storing of Materials

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

3.5.2 The Contractor will have to make his own arrangements for the storage of adequate quantity of cement. If such cement is not stored properly and has deteriorated, the material shall be rejected. Cement bags shall be stored in dry weatherproof shed with

a raised floor, well away from the outer walls and insulated from the floor to avoid moisture from ground. Not more than 15 bags shall be stacked in any tier. Storage arrangement shall be approved by the EMPLOYER. Storage under tarpaulins shall not be permitted. Each consignment of cement shall be stored separately and consumed in its order of receipt.

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

3.5.4 The Contractor shall make his own arrangements for storing water at site in tanks to prevent contamination.

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

3.6 Concrete

3.6.1 General

Concrete grade shall be as designated on drawings. In concrete grade M15, M20 etc. the number represents the specified characteristic compressive strength of 150 mm cube at 28 days, expressed in N/sq.mm as per IS:456. Concrete in the works shall be "DESIGN MIX CONCRETE" or "NOMINAL MIX CONCRETE". All concrete works of grade M5, M7.5 and M10 shall be NOMINAL MIX CONCRETE whereas all other grades, M15 and above, shall be DESIGN MIX CONCRETE.

3.6.1a Ready mix concrete

Minimum cement consumption shall be as specified in tender document. However, necessary computer print out for consumption of all materials an admixtures if permitted shall be made available as and when required in any frequencies as directed by Engineer –in-charge.

Necessary slump requirements at the pouring places shall be made available with ready mix concrete.

Concrete mix shall be design for 33% higher strength than the grade of concrete specified. The proportions for ingredients chosen shall be such that concrete has adequate workability for condition prevailing on the work in question and can be properly compacted with the means available. Use of cementacious material like Fly ash etc. shall not be permissible.

Except where it can be shown to the satisfaction of the Engineer-in-charge that a supply of properly graded aggregate of uniform quality can be maintained till the completion of work, grading of aggregate should be strictly controlled. The different sizes shall be stocked in separate stock piles. Required quality of material shall be stock-piled several hours, preferably a day, before use. Grading of coarse and fine aggregate shall be checked as frequently as possible, frequency for a given job being

determined by the Engineer-in-charge to ensure that the suppliers are maintaining the uniform grading as approved for samples use din the design mix.

The quantity of both cement and aggregate shall be determined by weight. Water shall either be measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be periodically checked.

It is most important to keep the specified water – cement ratio constants and its correct value. To this end, the moisture content in both fine and coarse aggregates shall be determined by the Engineer-in-charge according to the weather conditions. The amount of mixing water shall then be adjusted to compensate for variations in the moisture content. For the determination of moisture content in the aggregates, IS: 2386 (Part-III) shall be referred to. Suitable adjustments shall also be made in the weights of aggregates to allow for the variation in weights of aggregates due to variation in their moisture content.

The special Conditions / Specification regarding RMC are as follows.

The details like locations, capacity, experience, delivery schedule etc. of the RMC agency shall be submitted by the successfully tenderer for prior approval of the undersigned.

The RMC shall be conforming to IS :4926 with its latest amendments.

All the responsibility of RMC i.e. procurement for all materials, operation of plant and machinery, transit mixers, pumping machineries relevant piping etc. shall be on the account of the contractor.

The Client shall not be held responsible for any delay / damage / loss due to deployment of RMC for this project.

All taxes for the RMC shall have to be borne by the contractor as per prevailing rates.

RMC process shall be fully automatic and computerized

When a transit mixer is used for transportation of concrete, no extra water should be added to the concrete from else where after initial introduction of mixing water from the batch, except when on arrival at the site of the work, the slump of the concrete is less than that specified : such additional water to bring the mixer under such pressure and direction of flow that requirements for uniformity are met.

Records and certificates : The contractor shall keep from the manufacture batch records of the quantities by mass of all mixing and of the results of all tests. If required by the Client, the contractor shall furnish certificates, at agreed intervals, giving this information.

The contractor shall supply the following information for guidance of the manufacturer :

The type of cement to be used
Details Specification of aggregates to be used.
Type of admixture to be used. If specified.
Min. acceptable strength
Slump of concrete or compaction factor
Ages at which the test cubes or beams are to be tested and the frequency and number of test to be made.
Any other requirement.

Tolerance : Unless otherwise agreed to between the AMC and the contractor, the concrete shall be deemed to comply with the requirements of this, if these results of testes where applicable lie with in the tolerance specified below.

Consistency of workability : The slump average of two tests shall not differ from the specified value by + 10 mm for a specified slump of 75 mm. The compacting factor average of two test shall be within + 0.03 of the value specified. If any other method of determining consistency to be used a suitable tolerance shall be agreed to be between the purchaser and the manufacture. The tests for consistency or workability shall be complete within 15 minutes of the time of receipt of the ready mix concrete at the site.

Aggregate : When tested in accordance with IS 2386 (Part-I) 1963, the quantity of aggregate larger than the max size specified by the purchaser shall not exceed 5% of the qty. of coarse aggregate and all such pass sieve of next higher size.

If Ready Mix Concrete (RMC) is used for structural concrete work, mixed design as approved by employer should be got approved accordingly and stringent quality control to be done. Prior approval to be taken from employer in case of external RMC plant deployed by contractor for the selection of external RMC plant.

3.6.2 Design Mix Concrete

3.6.2.1 Mix Design & Testing

3.6.2.1.1 For Design Mix Concrete, the mix shall be designed according to IS:10262 and SP:23 to provide the grade of concrete having the required workability and characteristic strength not less than appropriate values given in IS:456. The design mix shall be cohesive and does not segregate and should result in a dense and durable concrete and also capable of giving the finish as specified. For liquid retaining structures, the mix shall also result in water tight concrete. The Contractor shall exercise great care while designing the concrete mix and executing the works to achieve the desired result.

3.6.2.1.2 The minimum cement content for Design Mix Concrete shall be as per Appendix-A of IS:456 or as given below, whichever is higher.

Grade of Concrete	Minimum Cement Content in Kg/Cu.m of Concrete

M15	320
M20	360
M25	380
M30	410

3.6.2.1.3 The minimum cement content stipulated above shall be adopted irrespective of whether the Contractor achieves the desired strength with less quantity of cement. The CONTRACTOR's quoted rates for concrete shall provide for the above eventuality and nothing extra shall become payable to the CONTRACTOR in this account. Even in the case where the quantity of cement required is higher than that specified above to achieve desired strength based on an approved mix design, nothing extra shall become payable to the CONTACTOR.

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

Grade of Concrete	**Minimum Compressive Strength N/sq. mm at 7 days**	**Specified Characteristic Compressive Strength N/sq. mm at 28 days**
M 15	10.0	15.0
M 20	13.5	20.0
M 25	17.0	25.0
M 30	20.0	30.0
M 35	23.5	35.0
M 40	27.0	40.0

3.6.2.1.5 A range of slumps which shall generally be used for various types of construction unless otherwise instructed by the EMPLOYER is given below :

Structure/Member	**Slump in millimeters**	
	Maximum	**Minimum**
Reinforced foundation walls and footings	75	25
Plain footings, caissons and substructure walls	100	25
Slabs, Beams and reinforced walls	75	25
Pump & miscellaneous Equipment Foundations	100	25
Building columns	50	25
Pavements	50	25
Heavy mass construction	50	25

3.6.2.2 Batching & Mixing of Concrete

3.6.2.2.1 Proportions of aggregates and cement, as decided by the concrete mix design, shall be by weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within one percent of the desired value.

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

3.6.2.2.3 Arrangement should be made by the Contractor to have the cubes tested in an approved laboratory or in field with prior consent of the EMPLOYER. Sampling and testing of strength and workability of concrete shall be as per IS:1199, IS:516 and IS:456, IS 3370.

3.6.3 Nominal Mix Concrete

3.6.3.1 Mix Design & Testing

Mix design and preliminary tests are not necessary for Nominal Mix Concrete. However works tests shall be carried out as per IS:456. Proportions for Nominal Mix Concrete and w/c ratio may be adopted as per Table 3 of IS:456. However it will be the Contractor's sole responsibility to adopt appropriate nominal mix proportions to yield the specified strength.

3.6.3.2 Batching & Mixing of Concrete

Based on the adopted nominal mixes, aggregates shall be measured by volume. However cement shall be by weight only.

3.7 Formwork

All formwork shall be designed as per IS:14687.

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

3.7.2 The design and engineering of the formwork as well as its construction shall be the responsibility of the Contractor. However, if so desired by the EMPLOYER, the drawings and calculations for the design of the formwork shall be submitted to the EMPLOYER for approval.

Formwork shall be designed to fulfill the following requirements :

(a) Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.
(b) Made of suitable materials.
(c) Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits.
(d) Capable of withstanding without deflection the worst combination of selfweight, reinforcement and concrete weight, all loads and dynamic effects arising from construction and compacting activities, wind and weather forces.
(e) Capable of easy striking out without shock, disturbance or damage to the concrete.
(f) Soffit forms capable of imparting a camber if required.
(g) Soffit forms and supports capable of being left in position if required.
(h) Capable of being cleaned and/or coated if necessary immediately prior to casting the concrete; design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

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

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

3.7.6 Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse, all forms shall be thoroughly scraped, cleaned, nails removed, holes suitably plugged, joints repaired and warped lumber replaced to the satisfaction of the EMPLOYER. The Contractor shall equip himself with enough shuttering to allow for wastage so as to complete the job in time.

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

3.7.8 Wire ties passing through beams, columns and walls shall not be allowed. In their place bolts passing through sleeves shall be used. Formwork spacers left insitu shall not impair the desired appearance or durability of the structure by causing spalling, rust staining or allowing the passage of moisture.

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

3.7.10 Where specified all corners and angles exposed in the finished structure shall have chamfers or fillets of 20 mm x 20 mm size.

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

3.7.12 The Contractor shall provide adequate props carried down to a firm bearing without overloading any of the structures.

3.7.13 The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering. If the shuttering for a column is erected for the full height of the column, one side shall be built up in sections as placing of concrete proceeds or windows left for placing concrete from the side to limit the drop of concrete to 1.0m or as approved by the EMPLOYER. The Contractor shall temporarily and securely fix items to be cast (embedments/ inserts) in a manner that will not hinder the striking of forms or permit loss of grout.

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

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

(a) Development of adequate concrete strength;
(b) Permissible deflection at time of striking form work;
(c) Curing procedure employed - its efficiency and effectiveness;
(d) Subsequent surface treatment to be done;
(e) Prevention of thermal cracking at re-entrant angles;
(f) Ambient temperatures; and
(g) Aggressiveness of the environment (unless immediate adequate steps are taken to prevent damage to the concrete).

3.7.16 Under normal circumstances (generally where temperatures are above 20^{o}C) forms may be struck after expiry of the time period given in IS:456 unless approved otherwise by the EMPLOYER. For Portland Pozzolana/slag cement the stripping time shall be suitably modified as approved by the EMPLOYER. It is the Contractor's responsibility to ensure that forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resist surface damage and any stresses arising during the construction period.

3.8 Reinforcement Workmanship

3.8.1 Reinforcing bars supplied bent or in coils shall be straightened cold without damage. No bending shall be done when ambient temperature is below 5^{o}C. Local warming may be permitted if steel is kept below 10^{o} C.

3.8.2 All bars shall be accurately bent gradually and according to the sizes and shapes shown on the drawings/ schedules or as directed by EMPLOYER.

3.8.3 Re-bending or straightening incorrectly bent bars shall not be done without the approval of the EMPLOYER.

3.8.4 Reinforcement shall be accurately fixed and maintained firmly in the correct position by the use of blocks, spacers, chairs, binding wire etc. to prevent displacement during placing and compaction of concrete. The tied in place reinforcement shall be approved by the EMPLOYER prior to concrete placement. Spacers shall be of such materials and designs as will be durable, not lead to corrosion of the reinforcement and not cause spalling of the concrete cover.

3.8.5 Binding wire shall be 16 gauge soft annealed wire. Ends of the binding wire shall be bent away from the concrete surface and in no case encroach into the concrete cover.

3.8.6 Substitution of reinforcement, laps/splices not shown on drawing shall be subject to EMPLOYER's approval.

3.9 Tolerances

3.9.1 Tolerance for formwork and concrete dimensions shall be as per IS:456 unless specified otherwise.

3.9.2 Tolerances specified for horizontal or vertical building lines or footings shall not be construed to permit encroachment beyond the legal boundaries.

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

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

3.10 Preparation Prior to Concrete Placement

3.10.1 Before concrete is actually placed in position, the inside of the formwork shall be cleaned and mould oil applied, inserts and reinforcement shall be correctly positioned and securely held, necessary openings, pockets, etc. provided.

3.10.2 All arrangements-formwork, equipment and proposed procedure, shall be approved by the EMPLOYER. Contractor shall maintain separate Pour Card for each pour as per the format enclosed.

3.11 Transporting, Placing and Compacting Concrete

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

3.11.2 In all cases concrete shall be deposited as nearly as practicable directly in its final position. To avoid segregation, concrete shall not be rehandled or caused to flow. For locations where direct placement is not possible and in narrow forms the Contractor shall provide suitable drops and "Elephant Trunks". Concrete shall not be dropped from a height of more than 1.0m.

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

3.11.4 While placing concrete the Contractor shall proceed as specified below and also ensure the following:

(a) Continuously between construction joints and pre- determined abutments.
(b) Without disturbance to forms or reinforcement.
(c) Without disturbance to pipes, ducts, fixings and the like to be cast in; ensure that such items are securely fixed. Ensure that concrete cannot enter open ends of pipes and conduits etc.
(d) Without dropping in a manner that could cause segregation or shock.
(e) In deep pours only when the concrete and formwork designed for this purpose and by using suitable chutes or pipes.
(f) Do not place if the workability is such that full compaction cannot be achieved.
(g) Without disturbing the unsupported sides of excavations; prevent contamination of concrete with earth. Provide sheeting if necessary. In supported excavations, withdraw the linings progressively as concrete is placed.
(h) If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.
(i) Ensure that there is no damage or displacement to sheet membranes.
(j) Record the time and location of placing structural concrete.

3.11.5 Concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer. Concrete shall be compacted during placing with approved vibrating equipment without causing segregation until it forms a solid mass free from voids thoroughly worked around reinforcement and embedded fixtures and into all corners of the formwork. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers. Vibrators shall not be allowed to come in contact with reinforcement, formwork and finished surfaces after start of initial set. Over-vibration shall be avoided.

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

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

3.12 Mass Concrete Works

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

3.13 Curing

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

(a) Premature drying out, particularly by solar radiation and wind;
(b) leaching out by rain and flowing water;
(c) rapid cooling during the first few days after placing;
(d) high internal thermal gradients;
(e) low temperature or frost;
(f) vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

3.13.2 All concrete, unless approved otherwise by the EMPLOYER, shall be cured by use of continuous sprays or ponded water or continuously saturated coverings of sacking, canvas, hessain or other absorbent material for the period of complete hydration with a minimum of 7 days. The quality of curing water shall be the same as that used for mixing.

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

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

3.14 Construction Joints and Keys

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

3.14.2 Dowels for concrete work, not likely to be taken up in the near future, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as approved by the EMPLOYER.

3.14.3 Before resuming concreting on a surface which has hardened all laitance and loose stone shall be thoroughly removed by wire brushing/hacking and surface washed with high pressure water jet and treated with thin layer of cement slurry for vertical joints and horizontal layers.

3.14.4 When concreting is to be resumed on a surface which has not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed

and a coat of cement slurry applied. On this, a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old work. Thereafter work shall proceed in the normal way.

3.15 Foundation Bedding

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

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

3.16 Finishes

3.16.1 General

The formwork for concrete works shall be such as to give the finish as specified. The Contractor shall make good any unavoidable defects as approved consistent with the type of concrete and finish specified; defects due to bad workmanship (e.g. damaged or misaligned forms, defective or poorly compacted concrete) will not be accepted. The Contractor shall construct the formwork using the correct materials and to meet the requirements of the design and to produce finished concrete to required dimensions, plumbs, planes and finishes. Inside and outside 15 mm thick smooth cement plaster in CM (1:3) with water proofing compound shall be done in all water retaining structures.

3.16.2 Surface Finish Type F1

The main requirement is that of dense, well compacted concrete. No treatment is required except repair of defective areas, filling all form tie holes and cleaning up of loose or adhering debris. For surfaces below grade which will receive waterproofing treatment the concrete shall be free of surface irregularities which would interfere with proper and effective application of waterproofing material specified for use.

3.16.3 Surface Finish Type F2

The appearance shall be that of a smooth dense, well- compacted concrete showing the slight marks of well fitted shuttering joints. The Contractor shall make good any blemishes.

3.16.4 Surface Finish Type F3

This finish shall give an appearance of smooth, dense, well-compacted concrete with no shutter marks, stain free and with no discolouration, blemishes, arises, airholes etc. Only lined or coated plywood with very tight joints shall be used to achieve this finish. The panel size shall be uniform and as large as practicable. Any minor blemishes that might occur shall be made good by the Contractor.

3.16.5 Integral Cement Finish on Concrete Floor

In all cases where integral cement finish on a concrete floor has been specified, the top layer of concrete shall be screeded off to proper level and tamped with tamper having conical projections so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface. Where specified, a floor hardener as approved by the EMPLOYER shall be supplied and used as recommended by the manufacturer.

3.17 Repair and Replacement of Unsatisfactory Concrete work

3.17.1 Immediately after the shuttering is removed, all the defective areas such as honey-combed surfaces, rough patches, holes left by form bolts etc. shall be inspected by the EMPLOYER who may permit patching of the defective areas or reject the concrete work.

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

3.17.3 Rejected concrete shall be removed and replaced by the Contractor at no additional cost to the Employer.

3.17.4 For patching of defective areas all loose materials shall be removed and the surface shall be prepared as approved by the EMPLOYER.

3.17.5 Bonding between hardened and fresh concrete shall be done either by placing cement mortar or by applying epoxy. The decision of the EMPLOYER as to the method of repairs to be adopted shall be final and binding on the Contractor. The surface shall be saturated with water for 24 hours before patching is done with 1:5 cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as approved by the EMPLOYER.

3.18 Vacuum Dewatering of Slabs

3.18.1 Where specified floor slabs, either grade or suspended, shall be finished by vacuum dewatering including all operations such as poker vibration, surface vibration, vacuum processing, floating and trowelling as per equipment manufacturers recommendation. The equipment to be used shall be subject to the EMPLOYER's approval.

3.19 Hot Weather Requirements

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

3.19.2 Adequate provisions shall be made to lower concrete temperatures which shall not exceed 40^{o} C at the time of placement of fresh concrete.

3.19.3 Where directed by the EMPLOYER, the Contractor shall spray non-wax based curing compound on unformed concrete surfaces at no extra costs.

3.20 Cold Weather Requirements

3.20.1 Concreting during cold weather shall be carried out as per Is : 7861 (Part II).

3.20.2 The ambient temperature during placement and upto final set shall not fall below 5 Deg.C. Approved antifreeze/accelerating additives shall be used where directed.

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

3.21 Liquid Retaining Structures

3.21.1 The Contractor shall take special care for concrete for liquid retaining structures, underground structures and those others specifically called for to guarantee the finish and water tightness.

3.21.2 The minimum level of surface finish for liquid retaining structures shall be Type F2. All such structures shall be hydro-tested.

3.21.3 The Contractor shall make all arrangements for hydro-testing of structure, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipe lines etc.

3.21.4 The Contractor shall also make all temporary arrangements that may have to be made to ensure stability of the structures during construction.

3.21.5 Any leakage that may occur during the hydro-test or subsequently during the defects liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other methods as may be approved by the EMPLOYER. All such rectification shall be done by the CONTRACTOR to the entire satisfaction of the EMPLOYER at no extra cost to the EMPLOYER.

3.22 Testing Concrete Structures for Leakage

3.22.1 Hydro-static test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by the EMPLOYER, as described below :

3.22.2 In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven day period for absorption after filling with water.

3.22.3 In the case of structures whose external faces are buried and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water

shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs. over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the watertightness of the structure. The EMPLOYER shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

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

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

3.23 Optional Tests

3.23.1 If the EMPLOYER feels that the materials i.e. cement, sand, coarse aggregates, reinforcement and water are not in accordance with the Specifications or if specified concrete strengths are not obtained, he may order tests to be carried out on these materials in laboratory, to be approved by the EMPLOYER, as per relevant IS Codes. Contractor shall have to pay for these tests.

3.23.2 In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes do not give the stipulated strengths, the EMPLOYER reserves the right to order the Contractor to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, etc. The EMPLOYER also reserves the right to ask the Contractor to dismantle and re-do such unacceptable work, at no cost to the Employer. Alternately EMPLOYER also reserves the right to ask the CONTRACTOR to dismantle and re-do such unacceptable work at the cost of CONTRACTOR.

3.24 Grouting

3.24.1 Standard Grout

Grout shall be provided as specified on the drawings.
The proportion of Standard Grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. Surfaces to be grouted shall be thoroughly roughened and cleaned. All structural steel elements to be grouted, shall be cleaned of oil, grease, dirt etc. The use of hot, strong caustic solution for this purpose will be permitted. Prior to grouting, the hardened concrete shall be saturated with water and just before grouting, water in all pockets shall be removed. Grouting once started shall be done quickly and continuously. Variation in grout mixes and

procedures shall be permitted if approved by the EMPLOYER. The grout proportions shall be limited as follows :

Use	Grout Thickness	Mix Proportions	W/C Ratio (max)
a) Fluid mix	Under 25mm	One part Portland Cement to one part sand	0.44
b) General mix	25mm and over but less than 50mm	One part Portland Cement to 2 parts of sand	0.53
c) Stiff mix	50mm and over	One part Portland Cement to 3 parts of sand	0.53

3.24.2 Non-Shrink Grout

Non–shrink grout where required shall be provided in strict accordance with the manufacturer's instructions / specifications on the drawings.

3.24.3 General

3.24.3.1 Inspection

All materials, workmanship and finished construction shall be subject to continuous inspection and approval of EMPLOYER. Materials rejected by EMPLOYER shall be expressly removed from site and shall be replaced by Contractor immediately.

3.24.3.2 Clean-Up

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

3.24.3.3 Acceptance Criteria

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

a) properties of constituent materials;
b) characteristic compressive strength;
c) specified mix proportions;
d) minimum cement content;
e) maximum free-water/cement ratio;
f) workability;
g) temperature of fresh concrete;
h) density of fully compacted concrete;
i) cover to embedded steel;
j) curing;
k) tolerances in dimensions;
l) tolerances in levels;
m) durability;
n) surface finishes;

o) special requirements such as;
   i) water tightness
   ii) resistance to aggressive chemicals
   iii) resistance to freezing and thawing
   iv) very high strength
   v) improved fire resistance
   vi) wear resistance
   vii) resistance to early thermal cracking

3.24.4 The EMPLOYER's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the Contractor.

3.24.5 For work not accepted, the EMPLOYER may review and decide whether remedial measures are feasible so as to render the work acceptable. The EMPLOYER shall in that case direct the Contractor to undertake and execute the remedial measures. These shall be expeditiously and effectively implemented by the Contractor. Nothing extra shall become payable to the Contractor by the Employer for executing the remedial measures.

3.25 Waterstops

3.25.1 Material

The material for the PVC waterstops shall be a plastic compound with the basic resin of polyvinyl chloride and additional resins, plasticizers, inhibitors, which satisfies the performance characteristics specified below as per IS:12200. Testing shall be in accordance with IS:8543.

a)	Tensile strength	:	3.6 N/mm^2 minimum
b)	Ultimate elongation	:	300% minimum
c)	Tear resistance	:	4.9 N/mm^2 minimum
d)	Stiffness in flexure	:	2.46 N/mm^2 minimum
e)	Accelerated extraction		
i)	Tensile strength	:	10.50 N/mm^2 minimum
ii)	Ultimate elongation	:	250% minimum
(f)	Effect of Alkali	:	7 days
i)	Weight increase	:	0.10% maximum
ii)	Weight decrease	:	0.10% maximum
iii)	Hardness change	:	± 5 points
(g)	Effect of Alkali	:	28 days
i)	Weight increase	:	0.40% maximum
ii)	Weight decrease	:	0.30% maximum
iii)	Dimension change	:	±1%

3.25.2 PVC water stops shall be either of the bar type, serrated with centre bulb and end grips for use within the concrete elements or of the surface (kicker) type for external use.

3.25.3 PVC water stops shall be of approved manufacture. Samples and the test certificate shall be got approved by the EMPLOYER before procurement for incorporation in the works.

3.25.4 Workmanship

3.25.4.1 Waterstops shall be cleaned before placing them in position. Oil or grease shall be removed thoroughly using water and suitable detergents.

3.25.4.2 Waterstops shall be procured in long lengths as manufactured to avoid joints as far as possible. Standard L or T type of intersection pieces shall be procured for use depending on their requirement. Any non-standard junctions shall be made by cutting the pieces to profile for jointing. Lapping of waterstops shall not be permitted. All jointing shall be of fusion welded type as per manufacturer's instructions.

3.25.4.3 Waterstops shall be placed at the correct location/level and suitably supported at intervals with the reinforcement to ensure that it does not deviate from its intended position during concreting and vibrating. Care shall also be taken to ensure that no honey-combing occurs because of the serrations/end grips, by placing concrete with smaller size aggregates in this region. Projecting portions of the waterstops embedded in concrete shall be thoroughly cleaned of all mortar/ concrete coating before resuming further concreting operations. The projecting waterstop shall also be suitably supported at intervals with the reinforcement to maintain its intended position during concreting so as to ensure that it does not bend leading to formation of pockets. In addition, smaller size aggregates shall be used for concreting in this region also.

3.26 Preformed Fillers and Joint Sealing Compound

3.26.1 Materials

3.26.1.1 Preformed filler for expansion/isolation joints shall be non-extruding and resilient type of bitumen impregnated fibres conforming to IS:1838 (Part I).

3.26.1.2 Bitumen coat to concrete/masonry surfaces for fixing the preformed bitumen filler strip shall conform to IS:702. Bitumen primer shall conform to IS:3384.

3.26.1.3 Sealing compound for filling the joints above the preformed bitumen filler shall conform to Grade 'A' as per IS:1834.

3.26.2 Workmanship

3.26.2.1 The thickness of the preformed bitumen filler shall be 25mm for expansion joints and 50mm for isolation joints around foundation supporting rotatory equipment's. Contractor shall procure the strips of the desired thickness and width in lengths as manufactured. Assembly of small pieces/thicknesses of strips to make up the specified size shall not be permitted.

3.26.2.2 The concrete/masonry surface shall be cleaned free from dust and any loose particles. When the surface is dry, one coat of industrial blown type bitumen of grade 85/25 conforming to IS:702 shall be applied hot by brushing at the rate of 1.20 kg/sq.m. When the bitumen is still hot the preformed bitumen filler shall be pressed and held in position till it completely adheres. The surface of the filler against which further concreting/masonry work is to be done shall similarly be applied with one coat of hot bitumen at the rate of 1.20 kg/sq.m.

3.26.2.3 Sealing compound shall be heated to a pouring consistency for enabling it to run molten in a uniform manner into the joint. Before pouring the sealing compound, the vertical faces of the concrete joint shall be applied hot with a coat of bitumen primer conforming to IS: 3384 in order to improve the adhesive quality of the sealing compound.

3.26.2.4 Expansion joints between beams/slabs shall be provided with 100mm wide x 4mm thick mild steel plate at the soffit of RCC beams/slabs to support and prevent the preformed joint filler from dislodging. This plate shall be welded to an edge angle of ISA 50 x 50 x 6mm provided at the bottom corner, adjacent to the expansion joint of one of the beams/slabs, by intermittent fillet welding. Steel surfaces shall be provided with 2 coats of red oxide zinc chrome primer and 3 coats of synthetic enamel paint finish.

CONCRETE POUR CARD

POUR NO. :
DATE :
DRG. NO. :
STRUCTURE :
CONCRETE GRADE/QUANTITY/ :
MAX. AGGREGATE SIZE /
START / COMPLETION TIME :
SLUMP :

SL. NO.	ITEM				Remarks If Any
1.	BEFORE CONCRETING CENTRELINES CHECKED		YES/NO		
2.	FORMWORK AND STAGING CHECKED FOR ACCURACY, STRENGTH & FINISH		YES/NO		
3.	REINFORCEMENT CHECKED		YES/NO		
4.	COVER TO REINFORCEMENT CHECKED		YES/NO		
5.	VERIFIEDTEST CERTIFICATE FOR CEMENT/STEEL		YES / NO		
6.	ADEQUACY OF MATERIALS / EQUIPMENT FOR POUR		YES / NO		
7.	EMBEDDED PARTS (LOCATION & PLUMB) CHECKED	CIVIL	YES/NO		
		MECH.	YES/NO		
		ELEC.	YES/NO		

8.	SOFFIT(S) & POUR TOP(T) LEVELS CHECKED BEFORE (B) & AFTER (A) FORM REMOVAL (ONLY OF BEAMS OF OVER 10 M SPAN & IMPORTANT STRUCTURE LIKE T.G. ETC.)	S(B) T(B) S(B) T(B)	
9.	CONSTRUCTION JOINTS LOCATION & TIME (IF NOT AS PER DRAWING)		
10.	CEMENT CONSUMPTION IN KGS.		
11.	NUMBER OF CUBES AND IDENTIFICATION MARKS		
12.	TEST CUBE RESULTS (7 DAYS / 28 DAYS)		
13.	CONCRETE CONDITION ON FORM REMOVAL	V.GOOD/GOOD/FAIR /POOR	

Contractor's Representative EMPLOYER's Representative

NOTES: 1. EACH POUR TO HAVE SEPARATE CARDS, IN TRIPLICATE ONE EACH FOR CLIENT,CONTRACTOR & SITE OFFICE.

UNDER REMARKS INDICATE DEVIATIONS FROM DWGS. & SPECIFICATIONS, CONGESTION IN REINFORCEMENT IF ANY, UNUSUAL OCCURRENCES SUCH AS FAILURE OF EQUIPMENTS, SINKING OF SUPPORTS / PROPS. HEAVY RAINS AFFECTING CONCRETING, POOR COMPACTION, IMPROPER CURING, OTHER DEFICIENCIES, OBSERVATIONS ETC.

4.0 STRUCTURAL STEEL WORK

4.1 Applicable Codes and Specifications

4.1.1 The supply, fabrication, erection and painting of structural steel works shall comply with the following specifications, standards and codes unless otherwise specified herein. All standards, specifications and codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

1.	IS : 808	Dimensions for Hot Rolled Steel sections
2.	IS : 814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Maganese Steel
3.	IS : 800	Code of Practice for General Construction in Steel
4.	IS : 801	**Code of Practice for Use of Cold Formed Light Gauge Steel Structural Members in General Building Construction**
5.	IS : 806	Code of Practice for Use of Steel Tubes in General Building Construction
6.	IS : 7205	Safety Code for Erection of Structural Steel Work
7.	IS : 7215	Tolerances for Fabrication of Steel Structures
8.	IS : 4000	High Strength Bolts in Steel Structure – Code of Practice
9.	AISC	Specifications for Design, Fabrication and Erection of Buildings
10.	IS : 1161	Steel Tubes for structural purposes
11.	**IS:102**	**Ready Mixed paint, Brushing, Red Lead, Non-setting, Priming.**
12.	IS:110	Ready Mixed paint, brushing, grey filler for enamels for use over primers.
13.	IS:117	Ready Mixed paint, Brushing, Finishing, Exterior Semigloss for general purposes, to Indian Standard colours.
14.	IS:158	Ready Mixed paint, Brushing, Bituminous, Black, Lead free, Acid, Alkali and heat resisting.
15.	IS:159	Ready Mixed paint, Brushing, Acid resisting for protection against acid fumes, colour as required.
16.	IS:341	Black Japan, Types A, B and C
17.	IS:2339	Aluminium paint for general purposes, in Dual container
18.	IS:2932	Specification for enamel, synthetic, exterior, type 1, (a) undercoating, (b) finishing
19.	IS:2933	Specification for enamel, exterior, type 2, (a) undercoating, (b) finishing
20.	IS:5905	Sprayed aluminium and zinc coatings on Iron and Steel.
21.	IS:6005	Code of practice for phosphating of Iron and Steel.
22.	IS:9862	Specification for ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water & chlorine resisting.
23.	IS:13183	Aluminium paint, Heat resistant.
24.	SIS-05-5900	(Swedish Standard)
25.	IS : 1239	Mild steel tubes, tubulars and other Wrought steel fittings Part 1 – Mild steel tubes Part 2 – Mild steel tubulars and other wrought steel pipe fittings

26.	IS : 1363 (Parts 1 to 3)	Hexagon Head Bolts, Screws and Nuts of product Grade C (Size range M5 to M64)
27.	IS : 1367 (All parts)	Technical Supply Conditions for Threaded Fasteners
28.	IS : 1852	Rolling and Cutting Tolerances for Hot Rolled Steel Products
29.	IS : 1977	Structural Steel (Ordinary Quality)
30.	IS : 2062	Steel for General Structural Purposes
31.	IS : 2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming
32.	IS : 3502	Steel Chequered Plate
33.	IS : 3757	High Strength Structural Bolts
34.	IS : 5369	General Requirements for Plain Washers and Lock Washers
35.	IS : 5372	Taper Washers for Channels
36.	IS : 5374	Taper Washer for 1 Beams
37.	IS : 6610	Heavy Washers for Steel Structures
38.	IS : 8500	Structural Steel-microalloyed (medium and high strength qualities)
39.	IS : 803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded storage tanks
40.	IS : 816	Code of Practice for use of Metal Arc Welding for General construction in Mild Steel
41.	IS : 822	Code of Procedure for Inspection of Welds
42.	IS : 1182	Recommended Practice for Radiographic examination of Fusion – Welded Butt Joints in Steel Plates
43.	IS : 1200	Method of Measurement in Building Civil Works
44.	IS : 1477	Code of Practice for Painting of (Parts 1&2) Ferrous Metals in Buildings
45.	IS : 2595	Code of Practice for Radiographic Testing
46.	IS : 3658	Code of Practice for Liquid Penetrant Flaw Detection
47.	IS : 5334	Code of Practice for Magnetic Particle Flaw Detection of Welds
48.	IS : 9595	Recommendations for Metal Arc Welding of Carbon and Carbon Manganese Steel

4.2 Steel Materials

4.2.1 Steel materials shall comply with the referred to in **Sub-Clause 4.1**.

4.2.2 All materials used shall be new, unused and free from defects.

4.2.3 Steel conforming to IS:1977 shall be used only for the following :

Fe310-0(St 32-0)	For general purposes such as door/window frames, grills, steel gates, handrails, fence posts, tee bars and other non-structural use.
Fe410-0(St 42-0)	For structures not subjected to dynamic loading other than wind loads such as :Platform roofs, foot over bridges, building, factory sheds etc.

Fe510-0(St 42-0) Grade steel shall not be used

a) If welding is to be employed for fabrication
b) If site is in severe earthquake zone
c) If plastic theory of design is used

4.2.4 Drawings prepared by the VENDOR/CONTRACTOR

4.2.4.1 The VENDOR/CONTRACTOR shall prepare all fabrication and erection drawings for the entire work. All the drawings for the entire work shall be prepared in metric units. The drawings shall preferably be of one standard size and the details shown there in shall be clear and legible.

4.2.4.2 All fabrication drawings shall be submitted to the EMPLOYER for approval.

4.2.4.3 No fabrication drawings will be accepted for EMPLOYER's approval unless checked and approved by the VENDOR/CONTRACTOR's qualified structural engineer and accompanied by an erection plan showing the location of all pieces detailed. The VENDOR/CONTRACTOR shall ensure that connections are detailed to obtain ease in erection of structures and in making field connections.

4.2.4.4 Fabrication shall be started by the VENDOR/CONTRACTOR only after EMPLOYER's approval of fabrication drawings. Approval by the EMPLOYER of any of the drawings shall not relieve the VENDOR/CONTRACTOR from the responsibility for correctness of engineering and design of connections, workmanship, fit of parts, details, material, errors or omissions or any and all work shown thereon. The EMPLOYER's approval shall constitute approval of the size of members, dimensions and general arrangement but shall not constitute approval of the connections between members and other details.

4.2.4.5 The drawings prepared by the VENDOR/CONTRACTOR and all subsequent revisions etc. shall be at the cost of the VENDOR/CONTRACTOR for which no separate payment will be made.

4.3 Fabrication

4.3.1 General

4.3.1.1 All workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined/ground smooth true and square where so specified. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Unless otherwise approved by the EMPLOYER, reference may be made to relevant IS codes for providing standard fabrication tolerance. Material at the shops shall be kept clean and protected from weather.

4.3.2 Connections

4.3.2.1 Shop/field connections shall be as per approved fabrication drawings.

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

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

4.3.2.4 All connections and splices shall be designed for full strength of members or loads. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice.

4.3.2.5 All bolts, nuts, washers, electrodes, screws etc., shall be supplied/brought to site 10% in excess of the requirement in each category and size. Rates shall cover the cost of this extra quantity.

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

4.3.3 Straightening

4.3.3.1 All materials, shall be straight and, if necessary, before being worked shall be straightened and/or flattened by pressure and shall be free from twists. Heating or forging shall not be resorted to without the prior approval of the EMPLOYER in writing.

4.3.4 Rolling and Forming

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

4.3.5 High Strength Friction Grip Bolting

4.3.5.1 Inspection after tightening of bolts shall be carried out as stipulated in the appropriate standards depending upon the method of tightening and the type of bolt used.

4.3.6 Welding

4.3.6.1 Welding procedure shall be submitted to the EMPLOYER for approval. Welding shall be entrusted to qualified and experienced welders who shall be tested periodically and graded as per IS 817, IS : 7310 (Part 1) and IS : 7318 (Part 1).

4.3.6.2 While fabricating plated beams and built up members, all shop splices in each component part shall be made before such component part is welded to other parts of the members. Wherever weld reinforcement interferes with proper fit-up between components to be assembled off welding, these welds shall be ground flush prior to assembly.

4.3.6.3 Approval of the welding procedure by the EMPLOYER shall not relieve the Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

4.3.6.4 No welding shall be done when the surface of the members is wet nor during periods of high wind.

4.3.6.5 Each layer of a multiple layer weld except root and surfaces runs may be moderately penned with light blows from a blunt tool. Care shall be exercised to prevent scaling or flaking of weld and base metal from overpeening.

4.3.6.6 No welding shall be done on base metal at a temperature below –5 Deg.C. Base metal shall be preheated to the temperature as per relevant IS codes.

4.3.6.7 Electrodes other than low-hydrogen electrodes shall not be permitted for thicknesses of 32 mm and above.

4.3.6.8 All welds shall be inspected for flaws by any of the methods described under **Sub-clause 4.6.3**. The choice of the method adopted shall be agreed with the EMPLOYER.

4.3.6.9 The correction of defective welds shall be carried out in a manner approved by the EMPLOYER without damaging the parent metal. When a crack in the weld is removed, magnetic particle inspection or any other equally positive means approved by the EMPLOYER shall be used to ensure that the whole of the crack and material upto 25 mm beyond each end of the crack has been removed. The cost of all such tests and operations incidental to correction shall be borne by the Contractor.

4.4 Tolerances

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

4.4.2 Cutting, punching, drilling, welding and fabrication tolerances shall be generally as per relevant IS codes.

4.5 End Milling

4.5.1 Where compression joints are specified to be designed for bearing, the bearing surfaces shall be milled true and square to ensure proper bearing and alignment.

4.6 Inspection

4.6.1 General

4.6.1.1 The Contractor shall give due notice to the EMPLOYER in advance of the works being made ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for the EMPLOYER's inspection. The fact that certain material has been accepted at the Contractor's shop shall not invalidate final rejection at site by the EMPLOYER if it fails to conform to the requirements of these specifications, to be in proper condition or has fabrication inaccuracies which prevent proper assembly nor shall it invalidate any claim which the Employer may make because of defective or unsatisfactory materials and/or workmanship.

4.6.1.2 No materials shall be painted or despatched to site without inspection and approval by the EMPLOYER unless such inspection is waived in writing by the EMPLOYER.

4.6.1.3 The Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified.

4.6.1.4 For fabrication work carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. Inspection and testing shall be conducted in a manner satisfactory to the EMPLOYER.

4.6.1.5 Inspection and tests on structural steel members shall be as set forth below.

4.6.2 Material Testing

4.6.2.1 If mill test reports are not available for any steel materials the same shall be tested by the Contractor to the Employer's Representative's satisfaction to demonstrate conformity with the relevant specification.

4.6.3 Tests on Welds

4.6.3.1 Magnetic Particle Test

Where welds are examined by magnetic particle testing, such testing shall be carried out in accordance with relevant IS codes. If heat treatment is performed, the completed weld shall be examined after the heat treatment. All defects shall be repaired and retested. Magnetic particle tests shall be carried out using alternating current. Direct current may be used with the permission of the EMPLOYER.

4.6.3.2 Liquid Penetrant Inspection

In the case of welds examined by Liquid Penetrant Inspection, such tests shall be carried out in accordance with relevant IS Code. All defects shown shall be repaired and rechecked.

4.6.3.3 Radiographic Inspection

All full strength butt welds shall be radiographed in accordance with the recommended practice for radiographic testing as per relevant IS code.

4.6.4 Dimensions, Workmanship & Cleanliness

4.6.4.1 Members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements shown in the Contractor's approved fabrication drawings.

4.6.5 Test Failure

4.6.5.1 In the event of failure of any member to satisfy inspection or test requirement, the Contractor shall notify the EMPLOYER. The Contractor must obtain permission from the EMPLOYER before any repair `is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by the EMPLOYER.

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

4.6.5.3 The Contractor shall maintain records of all inspection and testing which shall be made available to the EMPLOYER.

4.7 Shop Matching

4.7.1 For structures like bunkers, tanks, etc. shop assembly is essential. For other steel work, such as columns along with the tie beams/bracings may have to be shop assembled to ensure satisfactory fabrication, obtaining of adequate bearing areas etc., if so desired by the EMPLOYER. All these shop assemblies shall be carriedout by the Contractor.

4.8 Drilling Holes for other works

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

4.9 Marking of Members

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

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

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

4.10 Errors

4.10.1 Any error in shop fabrication which prevents proper assembling and fitting up of parts in the field by moderate use of drift pins or moderate amount of reaming will be classified by the EMPLOYER as defective workmanship. Where the EMPLOYER rejects such material or defective workmanship, the same shall be replaced by materials and workmanship conforming to the Specifications by the Contractor, at no cost to the Employer.

4.11 Painting of Steel Works

All fabricated steel material, except those galvanised shall receive protective paint coating as specified in specification, which is described below.

4.11.1 Materials

4.11.1.1 Red-oxide – zinc chrome primer shall conform to IS:2074.

4.11.1.2 Synthetic enamel paint shall conform to IS : 2932.

4.11.1.3 Aluminium paint shall conform to IS:2339.

4.11.1.4 All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the EMPLOYER for the brand of manufacture and the colour/shade. All the materials shall be brought to the site in sealed containers.

4.11.2 Workmanship

4.11.2.1 Painting work shall be carried out only on thoroughly dry surfaces. Painting shall be applied either by brushing or by spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirement of IS:1477 (Part 2).

4.11.2.2 The type of paint, number of costs etc. shall be as specified in the respective items of work.

4.11.2.3 Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

4.11.2.4 All the surfaces shall be thoroughly cleaned of oil, grease, dirt, rust and scale. The methods to be adopted using solvents, wire brushing, power tool cleaning etc., shall be as per IS:1477 (Part – I) and as indicated in the item of work.

4.11.2.5 It is essential to ensure that immediately after preparation of the surfaces, the first coat of red oxide-zinc chrome primer shall be applied by brushing and working it well to ensure a continuous film without holidays. After the first coat becomes hard dry, a second coat of primer shall be applied by brushing to obtain a film free from 'holidays'.

4.11.2.6 After the second coat of primer is hard dry, the entire surface shall be wet rubbed cutting down to a smooth uniform surface. When the surface becomes dry, the undercoat of synthetic enamel paint of optimum thickness shall be applied by brushing with minimum of brush marks. The coat shall be allowed to hard-dry. The under coat shall then be wet rubbed cutting down to a smooth finish, taking adequate care to ensure that at no place the undercoat is completely removed. The surface shall then be allowed to dry.

4.11.2.7 The first finishing coat of paint shall be applied by brushing and allowed to hard-dry. The gloss from the entire surface shall then be gently removed and the surface dusted off. The second finishing coat shall then be applied by brushing.

4.11.2.8 Atleast 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the EMPLOYER.

4.12 Acceptance of Steel, its Handling & Storage

4.12.1 The Contractor shall carefully check the steel to be erected at the time of acceptance. Any fabrication defects observed should be brought to the notice of the EMPLOYER.

4.12.2 No dragging of steel shall be permitted. All steel shall be stored 300mm above ground on suitable packing to avoid damage. It shall be stored in the order required for erection, with erection marks visible. All storage areas shall be prepared and maintained by the Contractor. Steel shall not be stored in the vicinity of areas where excavation or grading will be done and, if so stored temporarily, this shall be removed by the Contractor well before such excavation and/or grading commences to a safe distance to avoid burial under debris.

4.12.3 Scratched or abraded steel shall be given a coat of primer in accordance with the Specifications for protection after unloading and handling prior to erection. All milled and machined surfaces shall be properly protected from rust/corrosion by suit able coating and also from damage.

4.13 Anchor Bolts & Foundations

4.13.1 The Contractor shall carefully check the location and layout of anchor bolts embedded in foundations constructed, to ensure that the structures can be properly

erected as shown on the drawings. Any discrepancy in the anchor bolts/foundation shall be reported to the EMPLOYER.

4.13.2 Leveling of column bases to the required elevation may be done either by providing shims or three nuts on the upper threaded portion of the anchor bolt. All shim stock required for keeping the specified thickness of grout and in connection with erection of structures on foundations, crane brackets or at any other locations shall be of good M.S. plates and shall be supplied by the Contractor at his cost.

4.13.3 A certain amount of cleaning of foundations and preparing the area is considered normal and shall be carried out by the Contractor at no extra cost.

4.13.4 Where beams bear in pockets or on walls, bearing plates shall be set and levelled as part of the work. All grouting under column base plates or beam bearing plates will be carried out by the Contractor.

4.14 Assembly & connections

4.14.1 Field connections may be effected either by riveting, bolting, welding or by use of high strength friction grip bolts as shown on the design and erection drawings.

4.14.2 All field connection work shall be carried as per the drawings. All bolts, nuts, washers, rivets, electrodes required for field connections shall be supplied by the Contractor free of cost.

4.14.3 All assembling shall be carried on a level platform.

4.14.4 Drifts shall be used only for drawing the work to proper position and must not be used to such an extent as to damage the holes. Size of drifts larger than the normal diameter of hole shall not be used. Any damaged holes or burrs must be rectified to the satisfaction of the EMPLOYER.

4.14.5 Corrections of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets shall be considered as a part of erection. Any error in the shop, which prevents proper fit on a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the EMPLOYER.

4.15 Erection

4.15.1 All structural steel shall be erected as shown on the drawings prepared by the Contractor. Proper size steel cable slings, etc., shall be used for hoisting. Guys shall not be anchored to existing structures, foundations, etc., unless so permitted by the EMPLOYER in writing. Care shall be taken to see that ropes in use are always in good condition.

4.15.2 Steel columns in the basement, if any, are to be lowered and erected carefully with the help of a crane and/or derrick without damaging the basement walls or floor.

4.15.3 Structural steel frames shall be erected plumb and true. Frames shall be lifted at points such that they are not liable to buckle and deform. Trusses shall be lifted only at node points. In the case of trusses, roof girders, all of the purlins and wind bracing shall be placed simultaneously and the columns shall be erected truly plumb on screed bars over the pedestals. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracings shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety and stability.

4.15.4 Chequered plates shall be fixed to supporting members by tack welding or by countersunk bolts as shown/specified in relevant drawings and/or as approved by the EMPLOYER. The edges shall be made smooth and no burrs or jagged ends shall be left. While splicing, care should be taken so that there is continuity in pattern between the two portions. Care should also be taken to avoid distortion of the plate while welding. The erection of chequered plates shall include :

a) Welding of stiffening angles/vertical stiffening ribs
b) Cutting to size and making holes to required shape wherever necessary to allow service piping and/or cables to pass through
c) Splicing as shown in relevant drawings
d) Smoothening of edges
e) Fixing of chequered plates by tack welding or by countersunk bolts
f) Providing lifting hooks for ease of lifting.

4.15.5 As erection progresses, the work shall be securely bolted to take care of all dead load, wind, seismic and erection stresses.

4.15.6 No riveting or welding or final bolting shall be done until the structure has been properly aligned and approved by the EMPLOYER. No cutting, heating or enlarging of the holes shall be carried out without the prior written approval of the EMPLOYER.

4.15.7 Test certificates shall be furnished by the Contractor.

4.16 Inspection

4.16.1 The EMPLOYER shall have free access to all parts of the job during erection and all erection shall be subjected to his approval. In case of faulty erection, all dismantling and re-erection required will be at the Contractor's cost. No paint shall be applied to rivet heads or field welds or bolts until these have been approved by the EMPLOYER.

4.17 Tolerances

4.17.1 General

Tolerances mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb.

4.17.2 Columns

Deviation of column axes at foundation top level with respect to true axes :	
(a) In longitudinal direction	±5 mm
(b) In lateral direction	±5 mm
Deviation in the level of bearing surface of columns at foundation top with respect to true level	±5 mm
Out of plumbness (verticality) of column axis from true vertical axis, as measured at column top :	
(a) For columns upto and including 15 metres in height	±1/1000 of column height in mm or ±15 mm whichever is less
(b) For columns exceeding 15 metres in height	±1/1000 of column height in mm or ±20 mm whichever is less
Deviation in straightness in longitudinal and transverse planes of column at any point along the height	±1/1000 of column height in mm or ±10 mm whichever is less
Difference in erected position of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance	±10mm
Deviation in any bearing or seating level with respect to true level	±5 mm
Deviation in differences in bearing level of a member on adjacent pair of columns both across and along the building	±10 mm

4.17.3 Trusses And Beams

Shift at the centre of span of top chord member with respect to the vertical plane passing through the centre of bottom chord	±1/250 of height of truss in mm or ±15 mm whichever is less
Lateral shift of top chord of truss at the centre of span from the vertical plane passing through the centre of supports of the truss	±1/1500 of span of truss in mm or ±15 mm whichever is less
Lateral shift in location of truss from its true vertical position	±10 mm
Lateral shift in location of purlin true position	±5 mm
Deviation in difference of bearing levels of trusses or beams from the true difference	i) ±20 mm for trusses ii) For beams : Depth < 1800mm : ±6mm Depth > 1800mm : ±10mm

Deviation in sag in chords and diagonals of truss between node points	1/1500 of length in mm or 10mm whichever is smaller
Deviation in sweep of trusses, beams etc. in the horizontal plane	1/1000 of span in mm subject to a maximum of 10 mm

4.17.4 Crane Girders & Rails

Shift in the centre line of crane rail with respect to centre line of web of crane girder	±5 mm
Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point	±5 mm
Difference in alignment of crane rail in plan measured between any two points 2 metres apart along rail	±1 mm
Deviation in crane track with respect to Time gauge	
(a) For track gauges upto and Including 15 metres	±5 mm
(b) For track gauges more than 15 metres	± [5 + 0.25 (S-15)] where S in metres is true gauge
Deviation in the crane rail level at any point from true level	±1/1200 of the gauge distance or ±10mm whichever is less
Difference in the crane rail actual levels between any two points 2 metres apart along the rail length	±2 mm
Difference in levels between crane track Rails at	
(a) Supports of crane girders	±15 mm
(b) Mid span of crane girders	± 20 mm
Relative shift of crane rail surfaces at a joint in plane and elevation	2 mm subject to grinding of surfaces for smooth transition
Relative shift in the location of crane stops (end buffers) along the crane tracks with track gauge S in mm	1/1000 of track gauge S in mm subject to maximum of 20 mm

4.17.5 Painting

After steel has been erected, all bare and abraded spots, rivet heads, field welds, bolt heads and nuts shall be spot painted with primer. Before paint is applied, the surface shall be dry and free from dust, dirt, scale and grease. All surfaces inaccessible after erection shall receive two coats of the approved paint before erection.

4.18 Clean up of Work site

During erection, the Contractor shall at all times keep the working and storage areas used by him free from accumulation of waste materials or rubbish. Before

completion of erection, he shall remove or dispose of in a satisfactory manner all temporary structures, waste and debris and leave the premises in a condition satisfactory to the EMPLOYER.

5.0 PLUMBING WORKS FOR WATER SUPPLY AND SANITARY ARRANGEMENTS

5.1 Applicable Codes

5.1.1 The following standards and codes are made a part of this Employer's Requirement. All standards, codes of practice referred to herein shall be the latest editions including all official amendments and revisions.

IS : 210 : Specification for grey iron castings
IS : 269 : Specification for ordinary and low heat portland cement
IS : 383 : Specification for coarse and fine aggregates from natural sources for concrete
IS : 432 : Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement
IS : 456 : Code of Practice for plain and reinforced concrete
IS : 458 : Concrete Pipes (with and without reinforcement).
IS : 516 : Methods of tests for strength of concrete
IS : 554 : Dimensions for pipe threads where pressure tight joints are required on the threads.
IS : 651 : Salt glazed stoneware pipes and fittings.
IS : 774 : Flushing Cisterns for water closets and urinals (valveless siphonic type)
IS : 775 : Cast iron brackets and supports for wash basins and sinks.
IS : 781 : Sand-cast brass screw-down bib taps and stop taps for water services.
IS : 783 : Code of practice for laying of concrete pipes.
IS : 1068 : Electroplated coatings of nickel and chromium of iron and steel.
IS : 1077 : Specification for common burnt clay building bricks
IS : 1786 : Specification for high strength deformed steel bars and wires for concrete reinforcement
IS : 1239 : Mild steel tubes (Part I) and mild steel tubulars and other wrought steel pipe fittings (Part II)
IS : 1536 : Centrifugally cast (spun) iron pressure pipes for water, gas and sewage.
IS : 1626 : Asbestos cement building pipes, gutters and fittings (spigot and socket types).
IS : 1703 : Copper Alloy float valves (horizontal plunger type) for water supply purposes.
IS : 1726 : Cast iron manhole covers and frames.
IS : 1729 : Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
IS : 1742 : Code of practice for buildings drainage
IS : 2116 : Specification for sand for masonry mortars
IS : 2212 : Code of practice for brickwork
IS : 2250 : Code of practice for preparation and use of masonry mortars

IS : 2326 : Automatic flushing cisterns for urinals
IS : 2470 : Code of practice for design and construction of septic tanks (Parts I & II)
IS : 2556 : Vitreous sanitary appliances (Part I to Part XV)
IS : 2963 : Specification for copper alloy waste fittings for wash basins and sinks
IS : 3006 : Specification for chemically resistant glazed stoneware pipes and fittings
IS : 3311 : Waste plug and its accessories for sinks and wash basins
IS : 5455 : Specification for cast iron steps for manholes
IS : 4127 : Code of Practice for laying of glazed stoneware pipes
IS : 3495 : Methods of tests of burnt clay building bricks
IS : 4111 : Code of practice for ancillary structures in sewerage system manholes
IS : 5382 : Specification for rubber sealing rings for gas mains, water mains and sewers
IS : 5329 : Code of practice for sanitary pipe work above ground for buildings
IS : 5434 : Non-ferrous alloy bottle traps for marine use

5.2 Sanitary Installation

5.2.1 The work shall be carried out complying in all respects with any specific requirements of the local body in whose jurisdiction the work is situated, and as approved by the Employer's Representative.

5.2.2 Any damage caused to the building, or to installations therein, either due to negligence on the part of the Contractor, or due to actual requirements of the work, shall be made good and the building or the installation shall be restored to its original condition by the Contractor.

5.2.3 All sanitary and plumbing work shall be carried out by licensed plumbers.

5.2.4 All sanitary appliances including sanitary fittings, fixtures, toilet requisites shall be of size, and design as approved by the Employer's Representative.

5.2.5 All white glazed porcelain fixtures, such as wash basin, sink drain board, water closet pan, urinal, `P' trap etc. shall have hard durable white glazed finish. They shall be free from cracks and other glazing defects. No chipped porcelain fixtures shall be used.

5.2.6 Joints between iron and earthenware pipes shall be made perfectly air and water tight by caulking with neat cement mortar.

5.3 Indian Type Water Closet

5.3.1 This shall be the long pan pattern with separate footrests made of white glazed earthenware, white glazed vitreous china or of white glazed fire clay. The general requirements shall conform to IS:2556 (Parts III and X). Each pan shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flush type. The flushing rim and inlet shall be of the self draining

type. It shall have a weephole at the flushing inlet to the pan. The flushing inlet shall be in the front, unless otherwise approved by the Employer's Representative. The inside of the bottom of pan shall have sufficient slope from the front towards the outlet and the surface shall be uniform and smooth enable easy and quick disposal while flushing. The exterior surface shall be unglazed and sufficiently rough or grooved at right angles to the axis of the outlet. Pans shall be provided with a trap `P' or `S' type with a minimum 50 mm water seal and 50 mm dia. vent horn. Pan shall be laid at the correct location and level over a bed of lime concrete using brick aggregates (1 part lime mortar to 2 parts brick bats with lime mortar to 2 parts of sand) or cement-sand admixture as specified in the drawings.

5.4 European Type Water Closet

5.4.1 Water closets shall be either of white glazed earthenware, white grazed vitreous china or white glazed fire clay as specified and shall be of "Siphonic Wash down type" conforming to IS.2556 (Part VIII). The closets shall be of one piece construction with approved plastic/bakelite seat and cover. Each water closet shall have 4 fixing holes having a minimum diameter of 6.5 mm for fixing to floor and shall have an integral flushing rim of suitable type. It shall also have an inlet of supply horn for connecting the flush pipe. The flushing rim and inlet shall be of the self-draining type. The water closet shall have a weephole at the flushing inlet. Each water closet shall have an integral trap with either "S" or "P" outlet with at least 50 mm water seal. The water closets shall have an antisiphonage 50 mm dia. vent horn on the outlet side of the trap. The inside of water closets and traps shall be uniform and smooth in order to ensure in efficient flush. The serrated part of the outlet shall not be glazed externally. The water closet when sealed at the bottom of the trap in line with the back plate, shall be capable of holding not less than 10 litres of water between the normal water level and the highest possible water level of the water closet installed.

5.5 Urinals

5.5.1 Urinals shall be of the bowl pattern, either flat back or angle back type lipped in front. They shall be of white glazed earthenware, white glazed vitreous china or white glazed fire clay, and of size as specified conforming to IS.2556 (Part VI). The urinals shall be of one piece construction. Each urinal shall be provided with not less than two fixings holes of a minimum dia. of 6.5 mm on each side. Each urinal shall have an integral flushing box rim of suitable type and inlet or supply horn for connecting the flush pipe. The flushing rim and inlet shall be of the self-draining type. It shall have a weephole at the flushing inlet of the urinal. At the bottom of the urinal, an outlet horn for connecting to an outlet pipe shall be provided. The exterior of the outlet horn shall not be glazed and the surface shall be provided with grooves at right angles to the axis of the outlet to facilitate fixing to the uniform and smooth throughout to ensure efficient flushing. The bottom of pan shall have sufficient slope from the front, towards the outlet such that there is efficient draining of the urinal. The waste fittings shall be chromium plated.

5.6 Wash Basins

5.6.1 Wash basins shall be of white glazed earthenware, white glazed vitreous china or white glazed fire clay as approved by the Employer's Representative and conforming to IS.2556

Type	Size
Flat Back	630 x 450 mm
Flat Back	550 x 400 mm

5.6.2 Wash basins shall be of one piece construction, including a combined overflow. All internal angles shall be designed so as to facilitate cleaning. Each shall have a rim sloping inside towards the bowl on all sides except skirting at the back. Basins shall be provided with single or double tap holes as approved. The tap holes shall be square. A suitable tap hole button shall be supplied if one tap hole is not required in installation. Each basin shall have a circular waste hole to which the interior of basin shall drain. The waste hole shall be either rebated or bevelled internally with diameter of 65 mm at top and a depth of 10 mm to suit a waste plug having 64 mm diameter. Each basin shall be provided with a non-ferrous 32 mm waste fittings. Stud slots to receive the brackets on the under side of the wash basins shall be suitable for a bracket with stud not exceeding 13 mm diameter, 5 mm high and 305 mm from the back of basin to the centre of the stud. The stud slots shall be of depth sufficient to take 5 mm stud. Every basin shall have an integral soap holder recess or recesses which shall fully drain into the bowl. The position of the chain stay-hole shall not be lower than the overflow slot. A slot type of overflow having an area of not less than 5 sq.cm. shall be provided and shall be so designed as to facilitate cleaning of the overflow. The Employer's Requirements for waste plug, chain and stay shall be the same as given for sinks.

5.6.3.1 All the waste fittings shall be chromium plated. Bottle trap shall conform to IS. 5434. The chromium plating shall be of service grade No. 2 conforming to IS.1068.

5.7 Sinks

5.7.1 The sinks shall be of white glazed earthenware, white glazed vitreous china or white glazed fire clay as approved by the Employer's Representative conforming to IS.2556 (Part V) and shall be of the following sizes:

450 x 300 x 150 mm
600 x 450 x 200 mm

5.7.2 They shall be of one piece construction, including a combined overflow. The floor of the sink shall gently slope towards the outlet. The outlet shall in all cases be suitable for waste fittings having flange of 64 mm diameter and the waste hole shall have a minimum diameter of 65 mm at the bottom to suit the waste fittings. The waste hole shall be either rebated or bevelled having a depth of 10 mm. Each sink shall be provided with a non-ferrous 40 mm dia. waste fitting. The sink shall have overflow of the weir type and the inverts shall be 30 mm below the top edge. Each sink shall be provided with a waste plug, of suitable dia. chain and stay. The plug shall be of rubber or other equally suitable material and shall be water tight when

fitted. Plug chains shall be of brass wire chromium plated. It shall have an overall length from the collar to the stay of not less than 300 mm. There shall be a triangular or D shackle at each end, one of which shall be brazed to the plug and the other securely fixed to the stay. The 150 mm long shank of the waste shall be threaded conforming to the requirements of IS.2556 for sinks only. The waste fittings and plug fittings shall be chromium plated. The chromium plating shall be of service grade No.2 conforming to IS.1068.

5.8 Flushing Cisterns

5.8.1 The flushing cisterns shall be automatic or manually operated, high level or low level, as approved by the Employer's Representative. For water closets and urinals high level cistern is intended to operate with minimum height of 125 cm and a low level cistern a maximum height of 30 cm between the top of the pan and the underside of the cistern. They shall be of cast iron, glazed earthenware, or pressed steel complying iron, glazed requirement of IS.774. Automatic flushing cistern for urinals shall conform to IS.2326.

5.9 Cast Iron Soil Waste and Vent Pipes and Fittings

5.9.1 All cast iron pipes and fittings shall be of uniform thickness with strong and deep sockets, free from flaws, air holes, cracks, sand holes and other defects and conform to IS.1536 . The diameter approved shall be internal diameter of pipe. The pipes and fittings shall be true to shape, smooth and cylindrical and shall ring clearly when struck over with a light hand hammer. All pipes and fittings shall be properly cleaned of all foreign material before being fixed.

5.9.2 All plug bends of drainage pipes shall be provided with inspection and cleaning caps, covers, which shall be fixed with nuts and screws. Pipes shall be fixed to the wall by W.I. or M.S. holder bat clamps, unless projecting ears with fixing holes are provided at socket end of pipe. The pipes shall be installed, truly vertical or to the lines and slopes as indicated. The clamps shall be fixed to the walls by embedding their hooks in cement concrete blocks (1:2:4) 10 cm x 10 cm making necessary holes in the walls at proper places. All holes and breakages shall be made good. The clamps shall be kept 25 mm clear of the finished face of the walls to facilitate cleaning and painting of pipes.

5.9.3 The annular space between the socket and spigot shall be filled with a gasket of hemp or spun yarn soaked in neat cement slurry. The joint shall then be filled with stiff cement mortar 1:2 (1 cement : 2 fine sand) well pressed with caulking tool and finished smooth on top at an angle of 45°. The joint shall be kept wet for not less then 7 days by tying a piece of gunny bag kept moist. Joints shall be perfectly air tight as well as water tight.

5.9.4 C.I. pipes and fittings which are exposed shall be first cleaned and then painted with a coat of red leadprimer. Two coats of zinc paint with white base and mixed with pigment of required colour to get the approved shade shall be given over the base primer coat.

5.9.5 The thickness of fittings and their socket and spigot dimensions shall conform to the thickness and dimensions approved for the corresponding sizes of straight pipes.

5.9.6 The connection between the main pipe and branch pipes shall be made by using branches and bends with access for cleaning. Floor traps shall be provided with 25 mm dia. puff pipe where the length of the waste is more than 1800 mm or the floor trap is connected to a waste stack through bends.

5.9.7 All cast iron pipes and fittings including joints shall be tested by a smoke test to the satisfaction of the Employer's Representative and left in working condition after completion. The smoke test shall be carried out as stated under :

5.9.8 Smoke shall be pumped into the pipe at the lowest and from a smoke machine which consists of a bellow and a burner. The material usually burnt is greasy cotton waste which gives out a clear pungent smoke which is easily detectable by sight as well as by smell if there is a leak at any point of the pipeline.

5.9.9 Water test and air test shall be conducted as stipulated in IS.5329.

5.10 Galvanised Mild Steel (G.I) Pipes

5.10.1 The pipes shall be galvanised mild steel welded pipes and seamless screwed and sockets tubes conforming to the requirements of IS.1239, for medium grade. They shall be of the diameter (nominal bore) approved. The sockets shall be designated by the respective nominal bores of the pipes for which they are intended. The pipes and sockets shall be finished neatly, well galvanised on both inner and outer surfaces, and shall be free from cracks, surface flaws, laminations and other defects. All screws, threads shall be clean and well cut. The ends shall be cut cleanly and square with the axis of the tube.

5.10.2 All screwed tubes and sockets shall have pipe threads conforming to the requirements of IS.554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

5.10.3 The fittings shall be of malleable cast iron or mild steel tubes complying with all the appropriate requirements as approved for pipes. The fittings shall be designated by the respective nominal bores of the pipes for which they are intended. The fittings shall have screw threads at the ends conforming to the requirements of IS.554. Female threads on fittings shall be parallel and male threads (except on running nipples and collars of unions) shall be tapered.

5.10.4 The pipes and fittings shall be inspected at site before use to ascertain that they conform to the specification. The defective pipes shall be rejected. Where the pipes have to be cut or rethreaded, the ends shall be carefully filled out so that no obstruction to bore is offered. The ends of the pipes shall then be threaded conforming to the requirements of IS.554 with pipe dies and taps carefully in such a manner as will not result in slackness of joints when the two pieces are screwed together. The taps and dies shall be used only for straightening bent and damaged screw threads and shall not be used for turning of the threads so as the make them

slack, water tight joint. The screw- thread of pipes and fittings shall be protected from damage until they are fitted.

5.10.5 The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped around the screwed end of the pipe. The end shall then be screwed in the socket, tee, etc., with the pipe wrench. Care should be taken that all pipes and fittings are properly jointed so as to make the joints completely water tight and pipes are kept at all times free from dust and dirt during fixing. Burrs from the joint shall be removed after screwing. After laying, the open ends of the pipes shall be temporarily plugged to prevent access of soil or any other foreign matter.

5.10.6 Any threads exposed after jointing shall be painted or in the case of underground piping thickly coated with approved anticorrosive paint to prevent corrosion.

5.10.7 For internal work the galvanised iron pipes and fittings shall run on the surface of the walls or ceiling (not in chase) unless otherwise specified. The fixing shall be done by means of standard pattern holder bat clamps, keeping the pipes about 1.5 cm clear of the wall. Pipes and fittings shall be fixed truly vertical/horizontal. When it is found necessary to conceal the pipes, chasing may be adopted or pipes fixed in the ducts of recesses etc. provided there is sufficient space to work on the pipes with the usual tools. The pipes shall not ordinarily be buried in walls or solid floors. Where unavoidable, pipes may be buried for short distances provided adequate protection is given against damage, but the joints in pipes shall not be buried. M.S. pipe sleeve shall be fixed at a place where a pipe is passing through a wall or floor for reception of the pipe and to allow freedom for expansion/contraction and other movements/maintenance. In case the pipe is embedded in walls or floors it should be painted with anti-corrosive bitumastic paint of approved quality. The pipe should not come in contract with lime mortar or lime concrete as the pipe is affected by lime. Under the floors the pipes shall be laid in layer of sand filling or as approved by the Employer's Representative.

5.10.8 G.I. pipes with socket and spigot ends shall be provided with lead caulked joints wherever specified and the joints shall conform to the requirements of IS.3114.

5.10.9 The work of excavation and backfilling shall be done true to line and gradient in accordance with general Employer's Requirements for earthworks in trenches for pipes laid underground.

5.10.10 The pipes shall be laid on a layer of 10.0 cm sand and filled upto 15 cm above the pipes. A sand cushion of 15cm on either side of the pipe shall also be provided. The remaining portion of the trench shall then be filled with excavated earth. The surplus earth shall be got rid of as directed. when excavation is done in rock the bottom shall be cut deep enough to permit the pipes to be laid on a cushion of sand 75 mm minimum.

5.10.11 The pipes and fittings after they are laid and jointed shall be subjected to hydrostatic pressure test as approved by the Employer's Representative and shall satisfactorily

pass the test. Pipe line system shall be tested in sections as the work proceeds, keeping the joints exposed for inspection. Pipes shall be slowly and carefully charged with water allowing all air to escape. All draw off taps shall then be closed and water pressure gradually raised to test pressure. Care shall be taken to ensure that pressure gauge is accurate and preferably should have been recalibrated before the test. Pump used having been stopped, the section of the pipeline shall maintain the test pressure for at least half an hour. Any joints or pipes found leaking shall be removed and replaced by the Contractor.

5.10.12 The G.I. pipe line shall be cut to the required length at the position where the meter and stop cock are required to be fixed. The ends of the pipes shall be threaded. The meter and stop cock shall be fixed in position by means of connecting pipe, G.I. nuts, sockets, etc. The stop cock shall be fixed near the inlet of the water meter. The paper disc inserted in the ripples of the meter shall be removed and meter installed exactly horizontally or vertically and with the arrow cast on the body of the meter pointing in the direction of flow. Care shall be taken that the factory seal of the meter is not disturbed. Whenever the meter is to be fixed to a newly fitted pipe line, the pipe line will have to be completely washed before fixing the meter. For this purpose, a connecting piece of pipe equal to the length of the meter is to be fixed on the new pipe line. The water shall be allowed to flow completely to wash the pipe line and then the meter installed as described above by replacing the connecting piece.

5.11 Stoneware Pipes and Fittings

5.11.1 All pipes with spigot and socket ends shall conform to IS.651/3006 and shall be of grade `A'. These shall be sound, free from visible defects such as fine cracks or hair cracks. The glaze of the pipes shall be free from crazing. The pipes shall give a sharp clear note when struck with a light hammer.

5.11.2 The following information shall be clearly marked on each pipe and fitting :

(a) Internal diameter;
(b) Grade;
(c) Date of manufacture;
(d) Name of manufacturer or his registered trade-mark or both.

All pipes and fittings shall have ISI mark.

5.11.3 Jointing of GSW pipes and fittings shall be done as per the requirements of the following Employer's Requirements and the relevant IS. After jointing, extraneous material if any, shall be removed from the inside of the pipes and fittings and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS : 5382.

5.11.4 Spigot and Socket Joint (Cement Joint)

5.11.4.1 The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. In each joint, spun yarn soaked in neat cement slurry or tarred gasket shall be passed around the joint and inserted in it by means of a caulking tool. More skeins of yarn or gasket shall be added if

necessary and shall be well caulked. Yarn or gasket so rammed shall not occupy more than one- fourth of the depth or socket.

5.11.4.2 Cement mortar (1:1) shall be slightly moistened and carefully inserted by hand into the remaining space of the joint after caulking of yarn or gasket. The mortar shall than be caulked into the joint with a caulking tool. More cement mortar shall be added until the space of joint has been completely filled with tightly caulked mortar. The joint shall then be finished of neatly outside the socket at an angle of 45 degrees.

5.11.4.3 The cement mortar joints shall be cured at least for seven days before testing.

5.11.4.4 The approximate quantity of cement required for each joint for certain common sizes of pipes are give below for guidance :

Nominal diameter of pipe (mm)	Cement (kg)
150	1.5
200	2.0
250	2.5
300	3.25
350	4.5
400	5.5
450	6.5

5.11.5 Spigot and Socket Joint (Bituminous Joint)

5.11.5.1 The general requirements for this type of joint shall be as specified in 5.12.1 The material for jointing shall consist of composition of asphalt and sand in the ratio of 1:7. Asphalt and sand shall be boiled together and filled into the socket in a molten state with the aid of special moulds.

5.11.6 Spigot and Socket Joint (Rubber Ring Joint)

5.11.6.1 The 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 rubber rings conforming to IS : 5382 shall be used, and the manufacturer's instructions shall be deemed to form a part of this 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.

5.11.7 Cleaning of Pipes

5.11.7.1 As soon as a stretch of GSW pipes has been laid complete from manhole to manhole or for a length as approved by the Employer’s Representative, the Contractor shall run through the pipes both backward and forward a double disc or solid or closed cylinder 50 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipeline shall be securely closed as approved by the Employer’s Representative to prevent entry of mud or silt etc.

5.11.7.2 If as a result of the removal of any obstruction the Employer's Representative considers that damages may have been caused to the pipe lines, he shall be entitled to order the length to be tested immediately. Should such test prove unsatisfactory the Contractor shall repair the pipeline and carry out such further tests as are required by the Employer's Representative.

5.11.7.3 It shall also be ascertained by the Contractor that each length from manhole to manhole or the length as approved by the Employer's Representative is absolutely clear and without any obstruction by means of visual examination of the interior of the pipeline suitably illuminated by projected sunlight or otherwise.

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

5.11.7.5 After the joints have thoroughly set and have been checked by the Employer's Representative and before backfilling the trenches, the entire section of the sewer or storm water drain shall be proved by the Contractor to be water tight. Before commencing the hydraulic test, the pipelines shall be filled with water and maintained full for 24 hours by adding water, if necessary, under a head of 0.6 m of water. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system with water. A knuckle bend shall be temporarily jointed at the top end and a sufficient length of vertical pipe jointed to it so as to provide the required test head; or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation. The pipeline shall be subjected to a test pressure of at least 2.5 m head of water at the highest point of the section under test. The tolerance of two litres per centimeter of diameter per kilometer may be allowed during a period of 10 minutes. 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.

5.11.7.6 If any damage is caused to the pipeline during the execution of work or while cleaning/testing the pipeline as specified. The Contractor shall be held responsible for the same and shall replace the damaged pipeline and re-test the same to the full satisfaction of the Employer's Representative.

5.11.7.7 Water for testing of pipeline shall be arranged by the Contractor.

5.12 Stop Cock and Bib Cock

5.12.1 A bibcock (bibtap) is a draw off tap with a horizontal inlet and free outlet and stopcock (stop tap) is a valve with a suitable means of connections for insertion in a pipe line for controlling or stopping the flow. They shall be of specified size and

shall be of the screw down type. The closing device should work by means of a disc carrying a renewable non-metallic washer, which shuts against water pressure on a seating at right angles to the axis of the threaded spindle which operates it. The handle shall be either crutch or butterfly type securely fixed to the spindle. The cocks shall open in anti-clockwise direction. When the bib cocks and stop cocks are required to be chromium plated, the chromium plating shall be of service Grade No. 2 conforming to IS.1068. in finish and appearance, the plated articles shall be free from plating defects such as blisters, pits, roughness and shall not be stained or discoloured.

5.12.2 These fittings shall be of brass heavy class, chromium plated (C.P) and of approved manufacture and pattern with screwed of flanged ends as specified. The fittings shall in all respects comply with the requirements of IS.781. The standard size of brass fittings shall be designated by the nominal bore of the pipe to which the fittings are attached. A sample of each kind of fitting shall be approved by the Employer's Representative and all supplies made according to the approved samples.

5.12.3 All cast fittings shall be sound and free from laps, blow holes and fittings, both internal and external surfaces shall be clean, smooth and free from sand etc. Burning, plugging stopping or patching of the casting shall not be permitted. The bodies, bonnets, spindles and other parts shall be truly machined and when assembled the parts shall be axial, parallel and cylindrical with surfaces smoothly finished. The area of the waterway of the fittings shall not be less than the area of the nominal bore.

5.12.4 The fittings shall be fully examined and cleared of all foreign matter before being fixed. The fittings shall be fitted in the pipe line in a workman like manner. The joints between fittings and pipes shall be made leak- proof. The joints and fittings shall be leak proof when subjected to a pressure test approved by the Employer's Representative and the defective fittings and joints shall be replaced or redone.

5.13 Soak Pit

5.13.1 Soak pit shall be constructed at the location specified by the Employer's Representative. Earthwork excavation shall be carried out to the exact dimensions. Brick masonry lining with open joints shall be constructed in the pit upto 150 mm below the outlet pipeline. Brick masonry in cement mortar 1:6 shall be constructed above this level upto ground. Well burnt brick aggregates of nominal size 40 mm to 80 mm and coarse sand shall be filled within the chamber. Construction of pit lining and filling of the brick ballast shall progress simultaneously.

5.14 Manholes

5.14.1 Location

Manholes shall be constructed at places approved by the Employer's Representative.

5.14.2 Excavation

Excavation, shoring, dewatering etc. for the pits of manholes, laying of pipes and fittings/specials shall be done in accordance with Employer's Requirements described elsewhere in the document.

5.14.3 Bed Concrete

The bed concrete for manholes shall be done in accordance with Employer's Requirements described elsewhere in the document.

5.14.4 Bricks

5.14.4.1 Bricks used for construction of manholes shall conform to the relevant Indian Standards. They shall be sound, hard, homogeneous in texture, well burnt in kiln without being vitrified, table moulded, deep red, cherry or copper coloured, of regular shape and size and shall have sharp and square and parallel faces. The bricks shall be free from pores, chips, flaws or humps of any kind. Bricks containing ungrounded particles and/or which absorb water more than 1/6th of their weight when soaked in water for twenty-four hours shall be rejected. Overburnt or underburnt bricks shall be liable to rejection. The bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 50 kg/sq.cm. unless otherwise noted in drawings. The class and quality requirements of bricks shall be as laid down in IS : 1077.

5.14.4.2 The size of the brick shall be 23.0 x 11.5 x 7.5 cm. unless otherwise specified; but tolerance upto ± 3 mm in each direction shall be permitted. Only full size brick shall be used for masonry work. Brick bats shall be used only with the permission of Employer's Representative to make up required wall length or for bonding. Sample bricks shall be submitted to the Employer's Representative for approval and bricks supplied shall conform to approved samples. If required by the Employer's Representative, brick sample shall be tested as per IS : 3495 by Contractor. Bricks rejected by the Employer's Representative shall be removed from the Site within 24 hours.

5.14.5 Cement Mortar

5.14.5.1 Mortar for brick masonry shall be prepared as per IS : 2250. Manholes shall be constructed in brick masonry with cement mortar (1:2) unless otherwise specified. Gauge boxes for sand shall be of such dimensions that one bag containing 50 kg. of cement forms one unit. The sand shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be as approved by the Employer's Representative. If required by the Employer's Representative sand shall be thoroughly washed till it is free of any contamination.

5.14.5.2 For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry conditions. Water shall then be added and mixing continued to give a uniform mix of required consistency. Cement mortar shall be used within 25 minutes of mixing. Mortar left unused in the specified period shall be rejected.

5.14.5.3 The Contractor shall arrange for tests on mortar samples if so required by Employer's Representative. Retempering of mortar shall not be permitted.

5.14.6 Brick Masonry

5.14.6.1 All bricks shall be thoroughly soaked in clean water for atleast one hour immediately before being laid. The cement mortar for brick masonry work of manholes shall be in the proportion specified in 5.14.5. Brick work 230 mm thick and over shall be laid in English Bond unless otherwise specified. 115 mm thick brick work shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Bricks shall be laid with frogs uppermost.

5.14.6.2 All brickwork shall be plumb and square unless otherwise shown on drawing and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be levelled. The thickness of brick courses shall be kept uniform. For walls of thickness greater than 230 mm both faces shall be kept in vertical planes unless otherwise specified. All interconnected brickwork shall be carried out at nearly one level (so that there is uniform distribution of pressure on the supporting structure) and no portion of the work shall be left more than one course lower than the adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed) at an angle not exceeding 45 degrees. But in no case the level difference between adjoining walls shall exceed 1.25 M. Workmanship shall conform to IS : 2212.

5.14.6.3 Brick shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 12 mm by raking tools daily during the progress of work when the mortar is still green, so as to provide a proper key for the plastering to be done. When plastering is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top. If mortar in the lower courses has begun to set, the joints shall be raked out to a depth of 12 mm before another course is laid.

5.14.7 Cement Plaster

5.14.7.1 All joints in masonry shall be raked to a depth of 12 mm with hooked tool made for the purpose when the mortar is still green and in any case within 48 hours of its laying. The surface to be rendered shall be washed with fresh clean water free from all dirt, loose material, grease etc. and thoroughly wetted for 6 hours before plastering work is commenced. Concrete surfaces to be rendered will however be kept dry. The wall should not be too wet but only damp at the time of plastering. The damping shall be uniform to get uniform bond between the plaster and the wall.

5.14.7.2 The proportion of the cement mortar shall be as approved on relevant drawings. Cement shall be mixed thoroughly in dry condition and then just enough water

added to obtain a workable consistency. The quality of water, sand and cement shall be as per relevant I.S. The mortar thus mixed shall be used immediately and in no case shall the mortar be allowed to remain for more than 25 minutes after mixing with water.

5.14.7.3 Curing of plaster shall be started as soon as the applied plaster has hardened enough so as not to be damaged. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least 7 days.

5.14.7.4 Plastering shall be done on both faces of brick masonry in cement mortar (1:2) and 20 mm thick unless otherwise specified.

5.14.7.5 Plastering work shall be carried out in two layers, the first layer being 14 mm thick and the second layer being 6 mm thick. The first layer shall be dashed against the prepared surface with a trowel to obtain an even surface. The second layer shall then be applied and finished leaving an even and uniform surface, trowel finished unless otherwise approved by the Employer's Representative.

5.14.8 Cement Concrete Channel

5.14.8.1 The channel for the manhole shall be constructed in cement concrete of M15 grade. Both sides of the channel shall be taken up to the level of the crown of the outgoing sewer. They shall be benched up in concrete and rendered in cement mortar (1:1) of 20 mm thickness and formed to a slope of 1 in 12 towards the channel.

5.14.9 Pipe Entering or Leaving Manhole

5.14.9.1 Whenever a pipe enters or leaves a manhole, bricks on edge must be cut to a proper form and laid around the upper end of the pipe so as to form an arch. All around the pipes, there shall be a joint of cement mortar (1:2) 13 mm thick between it and the bricks.

5.14.10 Cast Iron Steps

5.14.10.1 Cast iron steps shall be as per IS : 5455. The steps shall be of grey cast iron of grade 15 as per IS : 210. The steps shall be clean, well cast and they shall be free from air and sand holes, cold shuts and warpings. The portion of the step which projects from the wall of the manhole shall have a raised chequered design to provide an adequate non-slip grip. C.I. steps shall weigh not less than 4.5 kg each and shall be of 150 mm x 375 mm overall dimensions. These steps shall be coated with a black bituminous composition. The coating shall be smooth and tenacious. It shall not flow when exposed to a temperature of 63 degrees C and shall not be brittle as to chip of at temperature of 0 degree C.

5.14.10.2 Where the depth of invert of manhole exceeds 800 mm, cast iron steps of approved pattern shall be fixed in the brick work at the interval of 300 mm vertically and staggered at 380 mm horizontally centre to centre. In case of pipe diameter greater than 600 mm, box type C.I. steps weighing 19 kg each shall be provided at 300 mm vertically in channel of manhole.

5.14.11 Frame and Covers

5.14.11.1 Frame and covers for manholes shall be of required type and dimensions as per the relevant drawings prepared by the Contractor. Following information shall be clearly marked on each cover.
Year of manufacture,
Identification mark of the Employer: EMPLOYER
Arrow showing direction of flow

5.14.11.2 Cast Iron Frame and Cover

The cast iron frame and cover shall be of grey cast iron as per IS : 1726. The general requirements for casting and coating of CI frame and cover shall be as specified for CI steps in Clause 5.15.10. The covers shall have a raised chequered design to provide an adequate non-slip grip. The rise of the chequer shall be not less than 4 mm. The locking device for the cover shall be provided as approved by the Employer's Representative. The CI covers for the load test shall be selected at one for every lot of fifty or part thereof for each type and size manufactured and as approved by the Employer's Representative. The frame shall be fixed in cement concrete of M15 grade all round and finished with neat cement. The manhole frame shall have 560 mm diameter clear opening and shall weigh not less than 208 kg. including cover. In case of rectangular CI frame and cover of 900 mm x 600 mm clear opening, the total weight shall not be less than 275 kg. In case of scraper manhole the frame shall have clear opening of 1200 mm x 900 mm and shall weigh not less than 900 kg including cover. The manhole cover and frame shall be painted with three coats of anti-corrosive paint after fixing in position.

5.14.11.3 Fibre Reinforced Concrete Frame and Cover

Fibre reinforced concrete frame and cover shall be capable of withstanding load of 35 tonnes. The frame shall be fixed in cement concrete of M15 grade all around and finished with neat cement. The fibre reinforced frame shall have clear opening of 560 mm diameter and weighing 102 kg. The cover shall have a minimum thickness of 100 mm and weighing 78 kg. The fibres shall constitute 1% of the weight of the concrete in the form of 50 mm to 100 mm long high tensile steel wires. For the cover, MS sheet lapping of 18 gauge shall be provided to avoid damage to the edges. Similarly for frame, MS angle/flat shall be provided along the edge. Both MS sheet and angle shall be painted with black bituminous paint. The cover should have suitable lifting arrangement. The fibre reinforced frame and cover shall be manufactured as approved.

5.14.11.4 Reinforced Cement Concrete Frame and Cover

Reinforced cement concrete frame and cover for manholes shall be of required dimensions and shape as shown on the drawing prepared by the Contractor. The frame and cover shall be cast in cement concrete of M25 grade. Minimum cover to the reinforcement shall be 40 mm. The edges of frame and covers shall be provided with mild steel angles to avoid damages to the corners. These angles

shall be painted with black bituminous paint. The covers should have suitable lifting arrangement.

5.14.12 Drop Manhole

5.14.12.1 When a sewer connects a main sewer, and where the difference in level between water line (peak flow levels) of main line and the invert level of branch lines is more than 600 mm or a drop of more than 600 mm is required to be given in the same sewer line and it is uneconomical or impractical to arrange the connection within 600 mm, a drop connection shall be provided for which a manhole shall be constructed as per relevant drawing, incorporating a vertical drop pipe from the higher sewer to the lower one. This pipe shall be provided outside the shaft and encased in concrete. A continuation of the branch sewer should be built through the shaft wall to form a rodding and inspection eye, which should be provided with a half blank flange. The diameter of the back drop should be at least as large as that of the incoming pipe. The drop pipe should terminate at its lower end with a plain or duck-foot bend turned so as to discharge its flow at 45 degrees or less to the direction of the flow in the main sewer. The pipe unless of cast iron should be surrounded with 150 mm thick concrete.

5.14.12.2 In the case of sewers over 450 mm in diameter the drop in level may be accomplished by one of the following approved methods:

(a) A cascade;
(b) A ramp;
(c) By drops in previous manholes.

5.14.13 RCC Manhole

5.14.13.1 M25 grade of concrete used for construction of RCC manhole shall have minimum cement content of 360 kg/cum of concrete. Minimum cover to the reinforcement shall be 50 mm.

5.14.14 Vent Shafts

5.14.14.1 General

Vent shafts shall be erected at such places as approved by the Employer's Representative.

5.14.14.2 Mild Steel Vent Shaft

Mild steel vent shaft shall be of 150 mm diameter and 12.17 m height from ground level with C.I. ornamental cap. This shall be fixed firmly and encased in cement concrete of M15 grade as shown on relevant drawing with necessary mild steel bolts, plates etc. for foundation. The vent shaft shall be painted with one coat of silver paint over one coat of red lead oxide paint. The vent shaft shall be connected to manhole by 150 mm diameter glazed stoneware pipe encased by

M10 concrete of 150 mm thickness all around as approved by the Employer's Representative.

5.14.14.3 RCC Vent Shaft

Reinforced cement concrete vent shaft shall be of M25 grade concrete, 200 mm diameter at bottom and tapered to 100 mm diameter at top (both inside clear openings) and 6 m height from ground level. The vent shaft shall be embedded in concrete of M10 grade and anchored by 2 nos. of 16 mm diameter and 600 mm long MS bars. The vent shaft shall be connected to manhole as specified in (b) above through a brick masonry flue chamber.

5.14.15 Miscellaneous

5.14.15.1 If any damage is caused to the other services such as water supply pipeline, sewer, cable, etc. during the construction of manholes and erection of vent shafts, the Contractor shall be held responsible for the same and shall replace the damaged services to the full satisfaction of the Employer's Representative.

5.14.15.2 The interior of manholes shall be cleared of all debris after construction and before testing the same for water tightness by the Contractor.

6.0 APPROACH AS WELL AS INTERNAL ROAD WORKS

(Part A) Flexible Pavement

6.1 Applicable Codes and Client's Requirements

The following specifications, standards and codes are referred to in this part.

IS : 73	:	Specification for Paving Bitumen
IS : 215	:	Specification for Road Tar
IS : 217	:	Specification for Cutback Bitumen
IS : 454	:	Specification for Digboi type Cutback Bitumen
IS : 460 (Parts 1 to 3)	:	Specification for Test sieves
IS : 1077	:	Common burnt clay building bricks - Specification
IS : 1124	:	Method of test for determination of water absorption, apparent specific gravity and porosity of building stones
IS : 1195	:	Specification for Bitumen Mastic for Flooring
IS : 1196	:	Code of Practice for Laying Bitumen Mastic Flooring
IS : 1834	:	Specification for Hot Applied Sealing Compounds for Joints in Concrete
IS : 2386 (Parts 1 to 8)	:	Methods of test for aggregates for concrete
IS : 2720 (Part 5)	:	Method of Test for Soils Determination of Liquid and plastic limit
IS : 6241	:	Method of test for determination of stripping value of road aggregates.
IRC : 16	:	Specification for priming of Base Course with Bituminous Primers.
IRC : 17	:	Tentative specification for Single Coat Bituminous Surface Dressing
IRC : 19	:	Standard specifications and code of practice for water bound macadam
IRC : 27	:	Specification for bituminous macadam
MoRTH	:	Specifications for road and bridge works

All earthwork shall be according to Employer's Requirements specified elsewhere.

6.1.1 Access to Abutting Propeties

For the duration of the works the contractor shall at all times provide convenient acess to paths, steps, bridge or drives for all entrances to property abutting the site and maintain them clear, tidy, and free from mud and objectionable matter

6.2 Road Construction

6.2.1 Road shall consist of the following :

a) Well compacted sub-grade layer.
b) Providing and laying sub-base of 260 mm thick with 40 mm to 90 mm size aggregates compacted to 200 mm thick in two layers with watering, rolling etc., as per specification complete.

c) Providing and laying base course of 105 mm size with 40 mm to 60 mm size aggregates compacted to 75 mm thickness in one layer with watering, rolling etc., as per specifications.
d) Providing and applying Prime Coat with bituminous emulsion (Slow Setting) at 7.5 kg/10Sqm
e) Providing and applying Tack Coat with bituminous emulsion (Rapid Setting) at 2.5 kg/10Sqm
f) Providing 70 mm compacted thickness of asphalt Macadam as per specification consisting of premixed asphaltic carpet and seal coat.

6.3 Materials

6.3.1 General

All materials shall be obtained from local sources and shall be subject to Employer's Representative's approval prior to use.

6.3.2 Soling Stone

It shall be clean, sound, dense, hard, tough, durable stone of uniform quality free from unsound material, cracks, decay and weathering. Water absorption shall not be more than 5 percent. The stone shall be in the smallest dimension equal to thickness of the soling course specified with a tolerance of 25 mm. Soling Stone shall be sufficiently flat bedded. The height of the soling stone shall be equal to the specified thickness of soling. The length and breadth shall not exceed twice the specified thickness.

6.3.3 Stone Aggregate/Metal

Coarse aggregate, stone chippings shall consist of natural or crushed stone, clean, hard, tough, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt, salt, alkali, vegetable matter, adherent coatings, organic and other objectionable matter, and shall conform to the physical requirements given in Tables 7.1 or 6.2 hereunder, as applicable. Aggregate for bituminous wearing courses shall in addition have good hydrophobic properties i.e. capacity of retaining the film of bituminous material applied to the stone in all weather conditions and especially in wet conditions. Basalt, dolerite are good in this respect; granite, quartzite are comparatively poor.

Table – 6.1 Physical Requirements of Coarse Aggregate for Water Bound Macadam (Sub Base/ Base Course)

Sl. No.	Test	Requirements	Test Method
1.	Los Angeles Abrasion Value* Or Aggregate Impact Value*	50 percent (max.) 40 percent (max.)	IS:2386 (Part – IV) IS:2386 (Part – IV) Or IS:5640***
2.	Flakiness Index **	15 percent (max.)	IS:2386 (Part I)

(*) Aggregate may satisfy requirements of either of two tests.

(**) Requirements of flakiness index shall be enforced only in case of crushed broken stone.

(***) Aggregates like brick, metal, kankar, laterite etc., which get softened in presence of water shall be tested for impact value under wet conditions in accordance with IS:5640.

Table – 6.2 Physical Requirements of Aggregates for Bituminous Wearing Course

Sl.No	Test	Requirements	Test Method
1.	Los Angeles Abrasion Value* Or Aggregate Impact Value*	40 percent (max.) 30 percent (max.)	IS:2386 (Part – IV) IS:2386 (Part – IV)
2.	Flakiness Index **	35 percent (max.)	IS:2386 (Part I)
3.	Stripping Value	25 percent (max.)	IS:6241
4.	Water Absorption	2 percent (max.)	IS:2386 (Part-III)
5.	Soundness Loss with Sodium Sulphate – 5 cycles Loss with Magnesium Sulphate – 5 cycles	 12 percent (max.) 18 percent (max.)	 IS:2386 (Part-V)

(*) Aggregate may satisfy requirements of either of two tests

(**) Requirement of flakiness index shall be enforced only in case of crushed broken stone

The coarse aggregate for water bound Macadam shall conform to one of the gradings given in Table-6.3 below :

Table – 6.3 Grading Requirements Of Coarse Aggregates For Water Bound Macadam

Grading No.	Size Range	Sieve Designation	Percent by Weight Passing the Sieve
1.	90mm to 45mm	125 mm 90 mm 63 mm 40 mm 22.4 mm	100 90-100 25-60 0-15 0-5
2.	63mm to 45mm	90 mm 63 mm 64 mm 65 mm 22.4 mm	100 90-100 25-75 0-15 0-5
3.	53mm to 22.4 mm	63 mm 64 mm 65 mm 22.4 mm 11.2 mm	100 95-100 65-90 0-10 0-5

6.3.4 Screenings for Water Bound Macadam

Screenings to fill voids in the coarse aggregate shall consist of the same materials as the coarse aggregate. However, where permitted, predominantly non-plastic material such as murum or gravel (other than river borne material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent.

Screenings shall conform to the gradings set forth in Table – 6.4. Screenings of Type-A in Table-6.4 shall be used with coarse aggregate of grading 1 in Table – 6.3. Screenings of Type A or B, as approved, shall be used with coarse aggregates of grading 2. Type-B screenings shall be used with coarse aggregates of grading 3.

Table –6.4 Gradings For Screenings

Grading No.	Size Range	Sieve Designation	Percent by Weight Passing the Sieve
A	12.5 mm	12.5 mm 10.0 mm 4.75 mm 150 micron	100 90-100 10-30 0-8
B	10 mm	10 mm 4.75 mm 150 micron	100 85-100 10-30

a) The use of screening shall be omitted in the case of soft aggregates such as brick metal, kankar, laterites etc. as they are likely to get crushed to a certain extent under rollers.

6.3.5 Binding Material

6.3.5.1 Binding material shall comprise of a suitable material, approved by Employer's Representative, have plasticity index value of less than 6 as determined in accordance with IS : 2720 (Part - V)

6.3.5.2 Application of binding material may not be necessary, when the screenings used are of crushable type such as murum or gravel.

6.3.6 Murum/Kankar/Gravel/Sand

6.3.6.1 Murum shall contain low plasticity binder material mixed with hard granular particles such as sand and/or gravel. Murum shall be sound and hard of a quality not affected by weather, to be screened at the quarry and free from all impurities. Large lumps shall all be broken at the quarry and murum delivered at site must pass in every direction through a 63 mm ring. Murum shall not contain more than 5% to 8% of fines passing a 75 micron sieve.

6.3.6.2 Gravel shall be composed of large, coarse, silicious grains, sharp and gritty to the touch, thoroughly free from dirt, organic and deleterious matter. It shall be hard,

tough, dense and shall not contain particles bigger than 12 mm and more than 10 percent silt.

6.3.6.3 Sand used for blinding the bituminous road surface, shall be coarse, sharp, gritty, clean, granular material. Only material passing through 4.75 mm sieve and retained on 75 micron sieve shall be used.

6.3.7 Bituminous Materials

6.3.7.1 Bituminous materials shall conform to IS : 73, IS : 215, IS : 217 or IS : 454 as applicable and be of the grade specified.

6.4 Earth work

6.4.1 Earthwork in Excavation

6.4.1.1 In general the excavation shall be in accordance to Employer's Requirement specified elsewhere.

6.4.1.2 Profiles of road excavation shall be laid at 50 m intervals to conform to the required alignment, sections, grades and side slopes and the lines of cuts shall be clearly marked.

6.4.1.3 Contractor shall on no account excavate beyond the slopes or below the specified grade unless so approved by the Employer's Representative in writing. If excavation is done below the specified level or outside the section the Contractor shall be required to fill up with approved materials, in layers of 150 to 200 mm, watered and compacted as specified for the subgrade.

6.4.1.4 The excavation shall be finished neatly, smoothly and evenly to the correct lines, grades, sections and side slopes as shown in the drawings or approved by Employer's Representative.

6.4.2 Earthwork in Embankment

6.4.2.1 The embankment shall be formed of earth obtained from approved source.

6.4.2.2 The ground over which embankment is to be formed shall be cleared of all brushwood, loose stones, vegetation, bushes, stumps, and all other objectionable matter and materials so removed shall be burnt off or disposed off as approved by Employer's Representative.

6.4.2.3 Profiles of embankment shall be set up with stout poles to mark the centre and edges of the formation with the top levels of formation clearly marked by paint or cut and the slopes with strings and pegs at every 10 metres on straight portions. Toe line may be marked with pick marks.

6.4.2.4 Before placing any embankment material the top 150 mm of soil strata receiving it shall be scarified and watered and compacted with one pass of 8-10T roller.

6.4.2.5 Embankment material shall be placed in successive horizontal layers of 200 mm depth extending to the full width of the embankment including the slopes at the level of the particular layer and 300 mm more on both sides to allow compaction of the full specified section. Before placing the next layer the surface of the underlayer shall be moistured and scarified with pick axes or spades to provide a satisfactory bond with the next layer. The extra loose stuff at the edges shall be trimmed later after completion of the bank work leaving the correct section fully compacted.

6.4.2.6 When boulders, broken stones and similar hard materials are mixed up with the embankment materials care shall be taken to see that they are distributed uniformly into the bank and that no hollows are left near them. No stone or hard material shall project above the top of any layer. Each layer of embankment shall be watered, leveled, and compacted as specified before the succeeding layer is placed. The surface of the embankment shall at all times during construction be maintained at such a cross fall as will shed water and prevent ponding.

6.4.2.7 If the bank materials contains less than the optimum moisture, water shall be added to the loose layers of the embankment to bring the moisture uniformly upto requirement. If the material contains more than the required moisture it shall be allowed to dry until the moisture is reduced to the required extent.

6.4.2.8 The moistured/dried loose layers shall be compacted with a power roller of 10 to 12 tonnes. The roller shall pass at least twice over the same area, once in the forward move and the second time in backward move.

6.4.2.9 To allow for subsequent settlement the finished level of the embankment shall be kept higher than the specified level by one centimetre for every metre of the height of the bank.

6.4.2.10 Embankment shall be finished and dressed smooth and even to conform to the alignment, levels, cross sections, and dimensions shown on drawings with due allowance for shrinkage. Any damage caused by rain, or due to any other reason shall be made good in the finishing operation.

6.5 Preparation of Subgrade

6.5.1 In general Earthwork in subgrade shall conform to Employer's Requirement specified elsewhere.

6.5.2 Immediately prior to the laying of the soling the subgrade shall be cleaned of all foreign substances, vegetation etc. Any ruts or soft yielding patches that appear shall be corrected and the subgrade dressed off parallel to the finished profile. The camber of subgrade shall conform in shape to that of the finished road surface. Camber boards shall be used to get the required section.

6.5.3 The prepared subgrade shall be lightly sprinkled with water, if necessary, and rolled with power roller of not less than 10 tonnes, till the soil is evenly compacted to 95% of Proctor density with 2% variation in optimum moisture content. Roller shall pass minimum 5 runs on the subgrade. Rolling shall commence at the edges and progress towards the centre longitudinally. Each pass of the roller shall uniformly overlap not

less than one third of the track made in the preceding pass. Any undulations in the surface that develop due to rolling shall be made good with approved earth and subgrade rerolled.

6.6 Soling

6.6.1 Soling shall not be constructed on a wet subgrade.

6.6.2 Unless otherwise specified, the width of the soling shall be 230 mm more on either side than that of the waterbound macadam wearing course and the finished thickness of the soling course shall be 230 mm.

6.6.3 The soling stones shall be laid with the largest face downwards and in contact with each other. The stones shall break joint as far as possible. The height of the soling stone shall be equal to specified thickness of soling.

6.6.4 As the laying of rubble advances the soling shall be hand packed by wedging and packing with 80 mm metal in the joints of the soling and driving them by hammers in place so as to fill the voids as completely as possible. This operation of hand packing shall closely follow the rubble laying. The soling shall be laid and hand packet true to grade and section and these shall be often checked by boning rods, template boards and fish line etc. The grades, sections etc. of the soling shall correspond to those of the surfacing coming on it. The soling thus laid shall be finished by knocking out projecting stones and filling depressions by chips to come up to the grade and camber.

6.6.5 The quality of the 80 mm metal shall be same as specified for the soling and the longest dimension shall not be more than 100 mm and the shortest dimension not less than 50 mm.

6.6.6 The soling after it is properly laid and hand packed including filling of voids with 80 mm metal shall be rolled dry with 10 - 12 T power roller to refusal i.e., till the stones in the soling course cease to move under the roller and no more compaction can be achieved. Rolling shall start at the edges and work towards the centre. The roller shall run over the same surface of rolling for at least 8 times till the soling course is well consolidated. The surface shall be checked by templates and in case of unevenness high spots shall be knocked out and depressions filled by spalls and recompacted fully. Bunds shall be laid along the edges and compacted before starting rolling on soling to prevent spreading of stones.

6.6.7 Gravel shall be spread in thin layers over the above prepared soling surface, swept into the interstices with brooms, watered lightly to assist the filling of voids. Spreading of gravel, sweeping and watering shall continue till the interstices are completely filled. At all times only enough water shall be sprinkled to force the gravel into the voids and never so much as to soften the subgrade. The process of gravel filling shall be accompanied by rolling as for dry rolling of soling with a power roller weighing not less than 10 tonnes starting at edge and working towards the centre. The roller shall run over the same surface for at least eight times. Each pass of the roller shall uniformly overlap not less than one third of the track made in

the preceding pass. The surface shall be checked with templates of approved design (to be provided by Contractor) and high and low spots corrected by removing soling and repacking.

6.7 Water Bound Macadam Course

The surface over which water bound Macadam is to be laid shall be prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm. To prevent the spreading of the course aggregate during rolling, if necessary, two parallel mud walls 200 mm wide and of height equal to uncompacted Macadam course shall be made along the outer edges of the Macadam course having a clear distance between them equal to the width to be metalled.

W.B.M. sub-base course of specified thickness shall be provided. The course aggregate for this shall conform to requirements of sub-base in Table-1 and its grading shall conform to Grading 1 of Table - 6.3 and screening to Type B of Table-6.4.

W.B.M. base course : The coarse aggregate for this shall normally conform to requirements for Base in Table-1 and its grading shall confirm to Grading 3 of Table – 6.3 and screening to Type-B of Table-6.4.

6.7.1 Spreading Coarse Aggregate

6.7.1.1 The coarse aggregate shall be spread uniformly and evenly upon the prepared surface in such quantities that the thickness of each compacted layer does not exceed 75 mm or as otherwise specified. In no case, however, shall the thickness of each compacted layer exceed 100 mm.

6.7.1.2 The spreading shall be done from stockpiles by raking the stacks with rakes so as to leave behind mud and dust. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over uncompacted or partially compacted sub-base/base be permitted. The surface of the aggregates spread shall be fully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. No segregation of large or fine aggregates shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material. The surface shall be checked frequently with a straight edge while spreading and rolling so as to ensure a finished surface as per approved plan. The coarse aggregate shall not normally be spread in lengths exceeding 3 days' average work ahead of the rolling and bonding of the proceeding section.

6.7.2 Rolling

6.7.2.1 Following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of not less than 10 tonne capacity or tandem or vibratory roller of approved type. Rolling shall begin from the edges and gradually progress towards the centre. First the edges/edge shall be compacted with roller running forward and backward and then move inwards parallel to the centre line of the road,

in successive passes uniformly lapping preceding tracks by at least one half width. Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. During rolling slight sprinkling of water may be done, if necessary. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or sub-base. The rolled surface shall be checked transversely and longitudinally with templates and all undulations shall be corrected by loosening the surface, adding or removing necessary amounts of aggregate and rerolling until the entire surface conforms to desired camber and grade. In no case shall the use of screenings be permitted to make up depressions. Material which crushed excessively during compaction or becomes segregated shall be removed and replaced with suitable aggregates. It shall be ensured that shoulders are also built-up simultaneously alongwith water bound macadam course.

6.7.3 Application of Screening

6.7.3.1 After the coarse aggregate has been rolled in accordance with Clause 6.9, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers. Screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all the voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand brooms or both. In no case shall screenings be applied so fast and thick as to form cakes and ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate. Spreading, rolling and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

6.7.4 Sprinkling and Grouting

6.7.4.1 After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued, with additional screenings applied as necessary, until the coarse aggregate has been thoroughly keyed, well bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the sub-grade or sub-base does not get damaged due to the addition of excessive quantities of water during construction. In case the subgrade or sub-base gets damaged, the Contractor shall rectify the damaged portion.

6.7.5 Application of Binding Material

6.7.5.1 After the application of screenings in accordance with Clauses 6.7.3 and 6.7.4, the binding material where it is required to be used (See Clause 6.3.5) shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry

swept in with hand brooms or mechanical brooms to fill the voids properly and rolled, during which water shall be applied to the wheels of the rollers, if necessary, to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

6.7.6 Setting and Drying

6.7.6.1 After the final compaction of water bound Macadam course it shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as approved, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the Macadam has set.

6.7.7 Multiple Layered Course

6.7.7.1 When the total consolidated thickness of the water bound Macadam course is more than 100 mm, it shall be constructed in layers. Each layer shall be constructed as per all the operations described above. The same degree of quality control and refinement shall be used for constructing each layer.

6.8 Premixed Asphaltic Carpet

This work shall consist of constructing in a single course of 20 mm thick Premixed Asphaltic Carpet on 50 mm thick Bituminous macadam to the following Employer's Requirements on a previously prepared base, to serve as a wearing coat.

6.8.1 Materials

(a) Binder
This shall be paving bitumen of penetration grade within the range S 35 to S 90 or A 35 to A 90 (30-40 to 80/100) as per Indian Standard for `Paving Bitumen' IS : 73. The actual grade of bitumen to be used shall be decided by the Employer's Representative appropriate to the region, traffic, rainfall and other environmental conditions.

(b) Course Aggregate
It shall be crushed material retained on 2.36 mm (No. 8 ASTM) sieve and shall be crushed stone or gravel (shingle) and shall be as per Clause 6.3.3 and satisfy the physical requirements set forth in Table-6.2.

(c) Fine Aggregates
The fine aggregates shall be the fraction passing 2.8 mm sieve and retained on 90 micron sieve consisting of crusher run screenings, natural sand or mixture of both. These shall be clean, hard, durable, uncoated, dry and free form any injurious, soft or flaky pieces and organic or deleterious substances.

(d) Filler
The filler shall be an inert material, the whole of which passing 710 micron, sieve, at least 90 percent passing 180 micron sieve and not less than 70 percent passing 90

micron sieve. The filler shall be stone dust, cement, hydrated lime, fly ash or any other non-plastic mineral matter approved by the Employer's Representative.

6.8.2 COMPOSITION OF BITUMINOUS MACADAM

The mineral aggregates including mineral filler shall be so graded or combined as to confirm to the either of the limits set forth in Table-6.5 below :

Table – 6.5 COMPOSITION OF BITUMINOUS MACADAM

Mix designation Nominal aggregate size Layer thickness IS Sieve (mm)	Grading 1 40mm 8 80-100mm Cumulative % by weight of total aggregate passing	Grading 2 19mm 50-75 mm
45	100	
37.5	90-100	
26.5	75-100	100
19	-	90-100
13.2	35-61	56-88
4.75	13-22	16-36
2.36	4-19	4-19
0.3	2-10	2-10
0.075	0-8	0-8
Bitumen content, % by weight of total mixture[1]	3.1-3.4	3.3-3.5
Bitumen grade	35 to 90	35 to 90

6.8.3 Mix Design

Apart from conformity with the grading and quality requirements of individual ingredients, the asphaltic concrete mix shall meet the requirements set forth in Table-6.6 hereunder.

6.8.4 Weather and Seasonal Limitations

Asphalt concrete shall not be laid during rainy weather or when the base course is damp or wet.

Table – 6.6 Requirement of Asphaltic Concrete Mix

Sr.No.	Description	Requirements
1.	Number of compaction blows, each end of Marshalling specimen	50
2.	Marshall stability (ASTM Designation-D-1559) determined on Marshal specimen	340 Kg. (min.)
3.	Marshall flow (mm)	2-4
4.	Percent Voids in mix	3-5
5.	Percent voids in mineral aggregate filled with bitumen	75-85

6.	Binder content percent by weight of mix	5-7.5

The contractor shall intimate to the Employer's Representative in writing, well in advance of the start of work, the job- mix formula proposed to be used by him for the work and shall give following details to the Employer's Representative for his approval.

i) Source and location of all materials
ii) Proportions of all materials expressed as follows where each is applicable :

Binder	As percentage by weight of total mix
Course aggregate	As percentage by weight of total aggregate including mineral filler
Fine aggregate	
Mineral filler	

iii) A single definite percentage passing each sieve for the mixed aggregate.
iv) The results of the best enumerated in Table-6.6 as obtained by the Contractor.
v) Test results of physical characteristics of aggregates to be used.

Should a change in the source of material be proposed, a new job mix formula shall be established and got approved from the Employer's Representative before actual using of the materials.

6.8.5 Preparation of Base

6.8.5.1 The base on which premix carpet is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section by repairing all potholes or patches and ruts. The potholes shall be drained of water and cut to regular shape with vertical sides. All loose and disintegrated material shall be removed. The pothole shall then be filled either with (i) Coarse aggregate and screenings conforming to Clause 3.0 and compacted with heavy hand rammers or approved mechanical tempers or (ii) premixed chippings binders (bitumen grade 80/100) content of 3 percent by weight of total mix, after painting the sides and bottom of the holes with a thin application of bitumen, or a combination of both (i), (ii) as approved by Employer/Employer's Representative. The surface shall be thoroughly swept and scraped clean and free of dust and other foreign matter.

6.8.6 Tack Coat

6.8.6.1 The binder used for tack coat shall be bitumen of suitable penetration grade within 80/100 confirming to IS:73. The actual grade of bitumen to be used shall be decided by the Employer's Representative, appropriate to the region, traffic, rainfall and other environmental conditions. Binder shall be heated to the temperature appropriate to its grade and as approved by the Employer's Representative. The binder shall be sprayed on the prepared base at the rate of 1.0 kg/sq.m. The binder shall applied uniformly with the aid of either self propelled or towed bitumen pressure sprayer with self heating arrangement and spraying nozzle arrangement

capable of spraying bitumen at the above specified rate and temperature so as to provide uniform unbroken spread of bitumen. The tack coat shall be applied just ahead of oncoming premixed asphalt carpet.

6.8.7 Preparation of Mix and Laying

6.8.7.1 Hot mix plant of adequate capacity and capable of producing a proper and uniform quality mix shall be used for preparing the mix. The plant may be either a weigh batch type or volumetric proportioning continuous or drum mix type. The stone aggregate shall be surface dry and contain not more than 2 percent moisture before use. It shall be first screened of dust and measured in boxes, heated to 155 deg.C - 163 deg. C and then loaded into the drum mixer according to the capacity of the mixing drum in the proportion specified. The binder shall be heated to 140 deg. C to 177 deg. C in boilers and maintained at that temperature. At no time shall the difference in temperature between the aggregate and binder exceed 14 deg. C. The heated binder shall be drawn from the boiler into a suitable container or in a bucket gauged to show the weight of bitumen in it.

6.8.7.2 Mixing shall be done in two stages. The coarse aggregate of the correct standard size and in the proportion as specified shall be fed into the mixer to which 2/3rd of the total specified quantity of bitumen heated to the appropriate temperature shall be added. When the coarse aggregate is well coated, the fine aggregate in the specified proportion followed by the balance 1/3rd quantity of total bitumen shall be fed into the mixer. Mixing shall be continued until a homogeneous mix is produced and all particles are uniformly coated with bitumen.

6.8.7.3 The hot mix shall be discharged from the mixer carried to the point of use in suitable tipper vehicles and shall be spread by means of a self propelled mechanical paver with a suitable screeds capable of spreading, tamping and finishing the mix to specified lines and levels to a thickness sufficient to achieve after consolidation the specified thickness. Temperature of the mix at the time of laying shall be in the range of 120 deg. C - 160 deg. C. However, in restricted locations and in narrow width where available equipment can not be operated in the opinion of the Employer's Representative, he may permit manual laying of the mix. Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centre line of the road. Longitudinal joints shall be offset by at least 150 mm from those in the binder course (tack coat). All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material.

6.8.8 Rolling

6.8.8.1 Immediately after the spreading of mix it shall be thoroughly compacted by rolling with a set of rollers moving at a speed not more than 5 km per hour. The initial or break down rolling shall be with 8-12 ton three wheel roller and the surface finished by final rolling with the 8-10 ton tendem roller. Preferably before finishing with tendem, breakdown rolling shall be followed by an intermediate rolling with a fixed wheel pneumatic roller of 15 to 30 ton having a tyre pressure of 7 kg. per sq.m. The joints and edges shall be rolled with a 8 to 12 ton three wheel roller. Any high spots

or depressions which become apparent shall be corrected by addition of removal of mix material. The roller shall uniformly overlap not less than a third of the track made in the preceding pass. The wheels of the roller shall be moistened with gunny bags to prevent the mix sticking to the wheels while rolling, but in no case shall fuel lubricating oil be used for this purpose. Rolling shall be continued till the mix is thoroughly compacted and all roller marks are eliminated.

6.8.9 Opening to Traffic

Traffic shall be allowed on the road after a lapse of minimum 24 hours, preferably 48 hours after laying as approved by the Employer's Representative.

6.9 Seal Coat

This work shall consist of application of a seal coat sealing the voids in a bituminous surface laid to the specified levels, grade and camber. Seal coat shall be either of the two types below :

Type A : Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chippings.

Type B : Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

6.9.1 Materials

6.9.1.1 Binder

This shall be 30/40, 60/70 or 80/100 grade straight run bitumen conforming to IS:73. The actual grade of bitumen to be used shall be approved by the Employer's Representative, appropriate to the region, traffic, rainfall and other environmental conditions. The quantity of binder to be utilized, shall be 9.8 kg and 6.8 kg per 10 sq.m. of area for Type A and Type B seal coat respectively.

6.9.1.2 Stone Chippings for Type A Seal Coat

These shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They should be free of elongated or flaky pieces, soft or disintegrated stone, vegetable or other deleterious matter. Stone chippings shall be of 10 mm size defined as 100 percent passing through 12.5 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cum per 10 sq.m.

6.9.1.3 Fine Aggregate for Type B Seal Coat

The fine aggregate shall be sand or fine grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky material organic matter or other deleterious substances. The aggregate shall pass 1.7 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cu.m. per 10 square metre area.

6.9.2 Preparation of Base

The seal coat shall be applied immediately after the laying of bituminous course which is required to be sealed. Before application of seal coat materials the surface shall be cleaned free of any dust or other extraneous matter.

6.9.3 Construction of Type A Seal Coat

6.9.3.1 Application of Binder

Binder shall be heated in boilers to 163 deg. C to 171 deg. C, maintained at the temperature and sprayed on the dry surface in a uniform manner with the help of mechanical sprayers. Excessive deposits of binder caused by stopping or starting of the sprayer through leakage or any other reason shall be suitably corrected before the stone chippings are spread.

6.9.3.2 Application of Stone Chipping

Immediately after the application of the binder, stone chippings in a dry and clean state shall be spread uniformly on the complete surface. If necessary the surface shall be broomed to ensure uniform spread of chippings. The surface shall be checked by means of a camber board laid across the road and a 3 metre straight edge laid parallel to the centre line of the road and undulations if any, shall be corrected by addition or removal of blindage.

6.9.3.3 Rolling

Immediately after the application of the cover the material, the entire surface shall be rolled with a 8 to 10 tonne smooth wheeled roller. While rolling is in progress additional material shall be spread by hand in whatever quantities required to make up irregularities. Rolling shall continue until all material is firmly bedded in the binder and presents a uniform closed surface. Generally five to six passes shall be made for thorough compaction of the surface or as approved by the Employer's Representative. Along kerbs, manholes and at all places not accessible to roller, thorough compaction shall be secured by means of steel rammers or hand rollers. Traffic shall be allowed after 24 hours. After a period of seven days, surplus grit shall be swept and collected and shall be used for binding the spots where bleeding occurs.

6.9.4 Construction of Type B Seal Coat

6.9.4.1 Preparation of Mix and Laying

The aggregate shall be surface dry and contain not more than 2 percent moisture before use, and shall be heated to 155 deg. C - 163 deg. C and then loaded into the drum mixer according to the capacity of the mixing drum in the proportion specified. The binder shall be heated to 149 deg. C to 177 deg. C in boilers and maintained at that temperature. At no time shall the difference in temperature between the aggregate and binder exceed 14 deg. C. The heated binder shall be drawn from the boiler into a suitable container or in a bucket gauged to show the weight of bitumen in it. The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

6.9.4.2 Rolling

As soon as sufficient length has been covered with the premixed material, the surface shall be rolled with 8 to 10 tonne smooth wheeled power rollers. Rolling shall be continued till the premixed material completely seals the voids in bituminous course and a smooth uniform surface is obtained.

6.9.4.3 Opening to traffic

Traffic may be allowed soon after final rolling when, the premixed material has cooled down to the surrounding temperature.

6.10 Quality Control

6.10.1 General

6.10.1.1 All materials incorporated and all works performed shall be strictly in conformity with the Specification requirements. All works shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as approved by the Employer's Representative subject to the permitted tolerances described hereinafter. The contractor shall be fully responsible for the quality of the work in the entire construction within the Contract. He shall, therefore, have his own independent and adequate set-up for ensuring the same.

6.10.1.2 The Contractor shall carry out quality control tests on the materials and work to the frequency specified. In the absence of clear indications about method and/or frequency of tests for any item, the approval of the Employer's Representative shall be obtained and he shall provide necessary co-operation and assistance in obtaining the samples for test and carrying out the field test as required by the Employer's Representative from time to time. This may include provision of Labour, attendance, assistance in packing and dispatching and any other assistance considered necessary in connection with the test.

6.10.1.3 For the work of embankment, subgrade and construction of subsequent layer of same or other material over the finished layer shall be done after obtaining approval from the Employer's Representative. Similar approval from the Employer's Representative shall be obtained in respect of all other items of works prior to proceeding with the next stage of construction.

6.10.1.4 The Contractor shall carry out modification in the procedure of work, if found necessary, as approved by the Employer's Representative during inspection. Works falling short of quality shall be rectified by the Contractor as approved by the Employer's Representative.

6.10.2 Permitted Tolerances

6.10.2.1 Horizontal Alignments

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ±25 mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be ±40 mm.

6.10.2.2 Longitudinal Profile

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross- profile of

the road shown on the drawings or as approved by the Employer's Representative beyond the tolerances mentioned below :

Subgrade	± 15 mm
Sub-base	± 20 mm
Base Course	± 15 mm
Wearing Course	± 10 mm

Provided, however, that the negative tolerance for wearing course shall not be permitted in conjunction with the positive tolerance for base course if the thickness of the former is thereby reduced by more than 6 mm.

6.10.2.3 Surface Regularity

The surface regularity of completed subgrade, sub-bases, base courses and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in Table 6.7.

The longitudinal profile shall be checked with a 3 metre long straight edge, at the middle of each traffic lane along a line parallel to the centre line of the road. The transverse profile shall be checked with a set of three camber boards at intervals of 10 metres.

6.10.2.4 Rectification

Where the surface irregularity of subgrade and the various courses fall outside the specified tolerances, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Employer's Representative.

i) Subgrade

Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by adding fresh material. The degree of compaction and the type of material to be used shall conform to the Clause 6.4.

ii) Water Bound Macadam

here the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompacted. The area treated at a place shall not be less than 5 metres long and 2 metres wide.

iii) Bituminous Constructions

For bituminous construction other than wearing course, where the surface is low, the deficiency shall be corrected by adding fresh material and recompacting to Employer's Requirements. Where the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to Employer's Requirements.

For wearing course, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to Employer's Requirements. In all cases where the removal and replacement of a bituminous layer is involved, the area treated shall not be less than 5 metre long and not less than 1 lane wide.

Table 6.7 Permitted Tolerance of Surface Regularity for Subgrade and Pavement Courses

Sl. No	Type of Construction	Longitudinal profile with 3 Cross profile metre straight edge					
		Maximum permissible undulation	Maximum number of undulations permitted in any 300 metres length exceeding : mm				Maximum permissible variation from specified profile under comber template : mm
1	2	3	4	5	6	7	8
1.	Earthen subgrade	24	30	-	-	-	15
2.	Granular/Lime/Cement/stabilised subbase	15	-	30	-	-	12
3.	Water bound macadam with over size metal (45-90 mm size)	15	-	30	-	-	12
4.	Water Bound Macadam with normal size metal (22-4-53 mm and 45-63 mm size)	12	-	-	30	-	8
5.	Bituminous macadam	8	-	-	-	10@@	4

Notes :

1. @@ These are for machine laid surfaces. If laid manually due to unavoidable reasons, tolerance upto 50 percent above these values in this column may be permitted at the discretion of the Employer's Representative. However, this relaxation does not apply to the values of maximum undulation for longitudinal and cross profiles mentioned in columns 3 and 8 on the table.
2. Surface evenness requirements in respect of both the longitudinal and cross profiles should be simultaneously satisfied.

6.11 Tests

6.11.1 General

6.11.1.1 For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Employer's Representative shall have the full authority to increase the frequencies of tests as he may deem necessary to satisfy himself that the materials and works comply with the appropriate Employer's Requirement.

6.11.1.2 Test procedures for the various quality control tests are indicated in the respective Sections of these Employer's Requirements or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as

per the prevalent accepted engineering practice to the approval of the Employer's Representative.

6.11.2 Tests on earthwork for Embankment and Subgrade Construction

(a) Borrow material

(i) Sand content [IS:2720(Part IV)]
1-2 tests per 8000 cu. metres of soil

(ii) Plasticity Test [IS:2720(Part V)]
Each type to be tested , 1-2 tests per 8000 cu. metres of soil.

(iii) Density Test [[IS:2720(Part VII)].
Each soil type to be tested, 1-2 tests per 8000 cubic metres of soil.

(iv) Deleterious Content Test [IS:2720(Part XXVII)]
As and when required by the Employer's Representative.

(v) Moisture Content Test [IS:2720(Part II)]
One test for every 250 cubic metres of soil.

(vi) CBR Test on materials to be incorporated in the subgrade on soaked/unsoaked samples [[IS:2720(part XVI)]

One test for every 3000 m3 at least or closer as and when required by the Employer's Representative.

(b) Compaction control : Control shall be exercised by taking at least one measurement of density for each 1000 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluation a days work on statistical basis. The determination of density shall be in accordance with IS:2720 (part XXVIII). Tests locations shall be chosen only through random sampling techniques. Control shall not be based on the result of any one test but on the mean value of a set of 5-10 density determinations. The number of tests in one tests in one set of measurements shall be 5 as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance of work shall be subject to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08 gm/cc.

However, for earthwork in shoulders (earthen) and in top 500 mm portion of the embankment below the subgrade, at least one density measurement shall be taken for every 50 square metres of the compacted area provided further `that the number of tests in each set of measurements shall be at least 10. In other respects, the control shall be similar to that described earlier.

6.11.3 Tests on Sub-bases and Bases
(Excluding bitumen bound bases)
The tests and their frequencies for the different types of bases and sub-base shall be as given in Table 6.8. The evaluation of density results for compaction control shall be on lines similar to those set out in clause 6.18.2

Table –6.8 Control Tests and Their Frequencies for Sub-Bases and Bases

(Excluding Bitumen Bound Bases)

Sl.No	Types of Construction	Test	Frequency
1.	Granular sub-base	i) Gradation ii) Atterbergs limit iii) Moisture content prior to compaction iv) Density of compacted layer v) Deleterious constituents vi) C.B.R	One test per 200 m^3 One test per 200 m^3 One test per 250 m^2 One test per 500 m^2 As required As required
2.	Lime/Cement Stabilised	vii) Purity of lime (for lime-soil stabilization viii) Lime/Cement content ix) Degree of pulverisation x) CBR test on a set of 3 specimens xi) Moisture content prior to compaction xii) Density of compacted layer xiii) Deleterious constituents	One test for each consignment subject to a minimum of one test per 5 tonnes of lime. Regularly, through procedural checks. Periodically as considered necessary. As required One test per 250 m^3. One test per 500 m^2 As required
3	Water Bound Macadam	xiv) Aggregate Impact Value xv) Grading xvi) Flakiness Index xvii) Atterbergs limits of binding material.	One test per 200m^3 of aggregate One test per 100 m^3 of aggregate One test per 200 m^3 of aggregate One test per 25 m^3 of binding material

6.11.4 Tests on Bituminous Constructions

The tests and their frequencies for the different types of bituminous works shall be as given Table 6.9 hereunder.

Table – 6.9 Control Tests and Their Frequency for Bituminous Works

Sl. No.	Types of Construction	Test	Frequency
1.	Prime Coat/Track Coat	i) Quality of binder ii) Binder temperature for a application iii) Rate of spread of binder	As Required As regular close intervals Two tests per day
2.	Seal Coat/Surface	iii) Quality of binder	As required

Sl. No.	Types of Construction	Test	Frequency
	Dressing	iv) Aggregate Impact Value	One test per 50 m^3 of aggregate
		v) Flakiness Index	One test per 50 m^3 of aggregate
		vi) Stripping value of aggregates	Initially, one set of 8 representative specimens for each source of supply.
		vii) Water absorption of aggregates	Subsequently when warranted by changes in the quality of aggregate
		viii) Grading of aggregates	One test per 25 m^3 of aggregate
		ix) Temperature of binder of application	At regular close intervals
		x) Rate of spread of materials	One test per 500 m^3 of aggregate
3	Bituminous Concrete/Macadam	xi) Quality of binder	As required
		xii) Aggregate impact value, flakiness index and stripping value of aggregates	One test per 50-100m^3 of aggregate
		xiii) Mix-grading	One set of test on individual constituents and mixed aggregates from the dryer for each 100 tonnes of mix subject to a maximum of two sets per plant per day.
		xiv) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling	At regular close interval.
		xv) Stability of mix (vide ASTM:D-1559)	For each 100 tonnes of mix produced, a set of three Marshall specimens to be prepared and tested for stability, flow value density, and void content, subject to a minimum of two sets being tested per plant per day.
		i) Binder content and gradation in the mix (Binder content test vide ASTM:D-2172)	
		ii) Rate of spread of mixed material	One test for each 100 tonnes of mix subject to a minimum of two tests per day per plant.
		iii) Density of compacted layer	Regular control through checks on the weight of

Sl. No.	Types of Construction	Test	Frequency
			mixed material and layer thickness. One test per 500 m^3 area

(Part B) C.C Pavement (Road)

Road shall consist of the following :

a) Well compacted sub-grade layer.

b) Providing and laying 100 mm thick PCC in M 10

c) Providing and laying 200 mm thick Concrete in M 20

d) TMT /Mild steel Reinforcement

e) Providing and applying Trimix with dewatering machine and floater machine

f) Groove Cutting & Filling with polysulfide selant

All the material shall confirm to the relevant Specification/ as per MORTh section 1000

Item of PCC ,RCC & TMT/Mild steel shall be executed as per relevant srelevant specification/MoRTh Specification

P/A Trimix with dewatering machine and floater machine on constructed Pavement
The purpose of vacuum processing is the removal of surplus water forms the concrete to provide quicker setting & earlier maximum strength properties. Vacuum dewatering takes place immediately after the screeding operation.

Upon the surface of the wet concrete is placed a filler pad consisting of two layers. The bottom layer is contract with the concrete is the fine nylon cloth to act as filler. The upper layer consists of a special type of plastic net & acts as a water duct. Finally the top cover consisting of a light plastic sheet is placed over the filler pad projecting slightly outside on all sides. The border of the top cover rests directly upon the wet concrete to produce an airtight seal.

The suction met is connected with suction houses to a vacuum pump. The normal atmospheric pressure in the pump is reduced by 90% & 90% of the atmospheric pressure compresses the concrete.

Concrete is submitted to a pressure of
Air pressure .1N / mm2
Depression .01N/mm2

= Effective pressure .09 N/ mm2

This pressure of about 9000 kp/m2 compresses the concrete & compacts the aggregates. At the same time the excess water which not necessary for the hydration process of the cement is extracted from the concrete & consciously discharged with the air.

Apart from normal compaction through vibration, static compaction takes place during vacuum dewatering with ensuring reduction w/c ratio. The initial w/c/ ratio is reduced by 10 to 20%. This explains the noticeable improvement s of the concrete properties achieved through vacuum dewatering.

Vacuuming time is about 1 to 2 min. per cm concrete thickness depending on the particle shape in the mix. M250

One vacuum pump with two suction met can dewater 50 to 60 m2. A 20 cm thick concrete slab takes about 30 min. dewater. Accordingly a normal daily production rate is about 400

m2.
Making groove in Pavement and filling it with polysulfide selant

General

All joints in surface slabs shall be sealed using **polysulfide** sealant. Joints shall not be sealed before -14 days after construction.

Preparation of joint grooves for sealing

Joint grooves usually are not constructed to provide the minimum width specified in the drawings when saw cut joints are adopted. They shall be widened subsequently by sawing before sealing, depth/width gauges shall be used to control the dimension of the groove.

If rough arises develop when grooves are made, they shall be ground to provide a chamfer approximately 5 mm wide. If the groove is at an angle upto 10 degree from the perpendicular to the surface, the overhanging edge of the sealing groove shall be sawn or ground perpendicular. If spalling occurs or the angle of the former is greater than 10 degrees, the joint sealing groove shall be sawn wider and perpendicular to the surface to encompass the defects upto a maximum width, including any chamfer, of 35 mm for transverse joints and 20 mm for longitudinal joints. If the spalling cannot be so eliminated then the arrises shall be repaired by an approved thin bonded arris repair using cementitious materials.

All grooves shall be cleaned of any dirt or loose material by air blasting with filtered, oil-free compressed air. If need-arises the Engineer may instruct cleaning by pressurised water jets. Depending upon the requirement of the sealant manufacturer, the sides of the grooves may have to be sand blasted to increase the bondage between sealant and concrete.

The groove shall be cleaned and dried at the Lime of priming and sealing.

Before sealing the temporary seal provided for blocking the ingress of dirt, soil etc., shall be removed. A highly compressible heat resistant paper-backed debonding strip as per drawing shall be inserted in the groove to serve the purpose of breaking the bond between sealant and the bottom of the groove and to plug the joint groove so that the sealant may not leak through the cracks. The width of debonding strip shall be more than the joint groove width so that it is held tightly in the groove. In the case of longitudinal joints, heat resistant tapes may be inserted to block the leakage through bottom of the joint.

Sealing with sealants

When sealants are applied, an appropriate primer shall also be used if recommended by the manufacturer and it shall be applied in accordance with their recommendation. The sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. Priming and sealing with applied sealants shall not be carried out when the naturally occurring temperature in the joint groove to be sealed is below 7° C.

If hot applied sealant is used it shall be heated and applied from a thermostatically controlled, indirectly heated preferably with oil jacketed melter and pourer having recirculating pump and extruder. For large road projects, sealant shall be applied with

extruder having flexible hose and nozzle. The sealant shall not be heated to a temperature higher than the safe heating temperature and not for a period longer than the safe heating period, as specified by the manufacturer. The dispenser shall be cleaned out at the end of each day in accordance with the manufacturer's recommendations and reheated material shall not be used.

Cold applied sealants with chemical formulation like polysulphide may be used. These shall be mixed and applied within the time limit specified by the manufacturer. If primers are recommended they shall be applied neatly with an appropriate brush. The Movement Accommodation Factor (MAP) shall be more than 10 per cent.

The sealants applied at contraction phase of the slabs would result in bulging of the sealant over and above the slab. Therefore, the Contractor in consultation with the Engineer, shall establish the right temperature and time for applying the sealant. Thermometer shall be hung on a pole in the site for facilitating control during the sealing operation.

Sealant shall be applied, slightly to a lower level than the slab with a tolerance of 5 ± 2 mm.

During sealing operation, it shall be seen that no air bubbles are introduced in the sealant either by vapours or by the scaling process.

Testing of applied sealants: Manufacturer's certificate shall be produced by the Contractor for establishing that the sealant is not more than six months old and stating that the sealant complies with the relevant standard as in Clause 602.2.8. The samples shall meet the requirement of AASHTO M 282 for hot applied sealant or BS 5212: (Pan-2) for cold applied sealant.

7.0 BUILDING DETAILS

7.1 Applicable Codes and Specifications

The following codes and standards are included in this section, as part of these specifications. However, respective IS codes for the works not mentioned here shall also be applicable for those particular items of work.

IS:110	-	Ready mixed paint, brushing, grey filler, for enamels for use over primers
IS:269	-	Specification for 33 grade ordinary portland cement
IS:280	-	Specification for mild steel wire for general engineering purposes
IS:287	-	Recommendations for maximum permissible moisture content of timber used for different purposes
IS:304	-	High Tensile Brass Ingots and Castings.
IS:337	-	Varnish, finishing interior
IS:348	-	French polish
IS:383	-	Specification for coarse and fine aggregates from natural sources for concrete
IS:412	-	Expanded metal steel sheets for general purposes
IS:419	-	Specification for putty for use on window frames
IS:428	-	Distemper, oil emulsion, colour as required

IS:459 - Specification for unreinforced corrugated and semi-corrugated asbestos cement sheets
IS:702 - Specification for industrial bitumen
IS:710 - Specification for marine plywood
IS:712 - Specification for building limes
IS:730 - Specification for hook bolts for corrugated sheet roofing
IS:733 - Wrought aluminium and aluminium alloys, bars, rods and sections for general engineering purposes
IS:777 - Specification for glazed earthenware tiles
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:1081 - Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators
IS:1124 - Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones
IS:1237 - Specification for cement concrete flooring tiles
IS:1322 - Bitumen felts for water proofing and damp proofing
IS:1346 - Code of practice for water proofing of roofs with bitumen felts
IS:1361 - Specification for steel windows for industrial buildings
IS:1397 - Specification for kraft paper
IS:1443 - Code of practice for laying and finishing of cement concrete flooring tiles
IS:1477 - Code of practice for painting of ferrous metals in buildings (Parts 1 & 2)
IS:1542 - Specification for sand for plaster
IS:1580 - Specification for bituminous compounds for water-proofing and caulking purposes
IS:1597 - Code of practice for construction of stone masonry : Part 1 Rubble stone masonry
IS:1659 - Specification for block boards
IS:1661 - Code of practice for application of cement and cement-lime plaster finishes
IS:1834 - Specification for hot applied sealing compound for joint in concrete
IS:1838 - Specification for preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type) : Part 1 Bitumen impregnated fibre
IS:1948 - Specification for aluminium doors, windows and ventilators
IS:1949 - Specification for aluminium windows for industrial buildings
IS:2074 - Ready mixed paint, air drying, red oxide- zinc chrome, priming
IS:2098 - Asbestos cement building boards
IS:2114 - Code of practice for laying in-situ terrazzo floor finish
IS:2116 - Specification for sand for masonry mortars
IS:2185 - Specification for concrete masonry units (Parts 1,2 & 3)
IS:2202 - Specification for wooden flush door shutters (Solid core type) : Parts 1 & 2
IS:2212 - Code of practice for brickwork
IS:2250 - Code of practice for preparation and use of masonry mortars

IS:2338 -	Code of practice for finishing of wood and wood based materials (Parts 1 & 2)
IS:2339 -	Aluminium paint for general purposes, in dual container
IS:2395 -	Code of practice for painting concrete, masonry and plaster surfaces (Parts 1 & 2)
IS:2402 -	Code of practice for external rendered finishes
IS:2571 -	Code of practice for laying in-situ cement concrete flooring
IS:2572 -	Code of practice for construction of hollow concrete block masonry
IS:2645 -	Specification of integral cement waterproofing compounds
IS:2690 -	Specification for burnt clay flat terracing tiles : Part 1 Machine made
IS:2691 -	Specification for burnt clay facing bricks
IS:2750 -	Specification for steel scaffoldings
IS:2835 -	Flat transparent sheet glass
IS:2932 -	Specification for enamel, synthetic, exterior type (a) undercoating, (b) finishing
IS:3007 -	Code of practice for laying of asbestos cement sheets - corrugated and (Part 1 & 2) semi-corrugated sheets
IS:3036 -	Code of practice for laying lime concrete for a water-proofed roof finish
IS:3067 -	Code of practice of general design details and preparatory work for damp-proofing and water- proofing of buildings
IS:3068 -	Specification for broken brick (burnt clay) coarse aggregates for use in lime concrete
IS:3384 -	Specification for bitumen primer for use in water-proofing and damp-proofing
IS:3461 -	Specification for PVC-asbestos floor tiles
IS:3462 -	Specification for unbacked flexible PVC flooring
IS:3495 -	Method of test for burnt clay building bricks: Part 1 to 4
IS:3536 -	Specification for ready mixed paint, brushing, wood primer, pink
IS:3564 -	Specification for door closures (hydraulically regulated)
IS:3614 - (Part - 1)	Specification for fire checks doors : Part –I Plate metal covered and rolling type
IS:3614 - (Part – 2)	Specification for metallic and non-metallic fire check doors : Part-2 Resistance test and performance criteria
IS:3696 -	Safety code of scaffolds and ladders (Parts 1 & 2)
IS:4020 -	Methods of test for wooden flush door : Type test
IS:4021 -	Specification for timber door, window and ventilator frames
IS:4351 -	Specification for steel door frames
IS:4443 -	Code of practice for use of resin type chemical resistant mortars
IS:4457 -	Specification for ceramic unglazed vitreous acid resisting tile
IS:4631 -	Code of practice for laying epoxy resin floor toppings
IS:4832 -	Specification for chemical resistant mortars (Part II)
IS:4860 -	Specification for acid resistant bricks
IS:4948 -	Specification for welded steel wire fabric for general use
IS:5318 -	Code of practice for laying of flexible PVC sheet and tile flooring
IS:5410 -	Cement paint, colour as required
IS:5411 -	Specification for plastic emulsion paint (Parts 1 & 2)

IS:5437 -	Wired and figured glass
IS:5491 -	Code of practice for laying of in-situ granolithic concrete floor topping
IS:6041 -	Code of practice construction of autoclaved cellular concrete block masonry
IS:6042 -	Code of practice for construction of light weight concrete block masonry
IS:6248 -	Specification for metal rolling shutters and rolling grilles
IS:7193 -	Specification for glass fibre base coal tar pitch and bitumen felts
IS:7452 -	Specification for hot rolled steel sections for doors, windows and ventilators
IS:8042 -	Specification for white portland cement
IS:8543 -	Methods of testing plastics
IS:8869 -	Specification for washers for corrugated sheet roofing
IS:9197 -	Specification for epoxy resin, hardeners and epoxy resin composites for floor topping
IS:9862 -	Specification for ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, water and chlorine resisting
IS:12200-	Code of practice for provision of waterstops at transverse contraction joints in masonry and concrete dams
BS : 476 - (Part – 20)	Methods for determination of the fire resistance of elements of construction (General Principles)
BS : 476 - (Part – 21)	Methods for determination of the fire resistance of load bearing elements of construction
BS : 476 - (Part – 22)	Methods for determination of the fire resistance of non-load bearing elements of construction
Part – IV - Fire Protection	National Building code of India

7.2 Brickwork

7.2.1 Materials

7.2.1.1 Bricks used in the works shall conform to the requirements laid down in IS: 1077. The class of the bricks shall be as specifically indicated in the respective items of work prepared by the Contractor.

7.2.1.2 The nominal size of the modular brick shall be 200mmx100mmx100mm with the permissible tolerances over the actual size of 190mmx90mmx90mm as per IS: 1077. The nominal thickness of one brick and half brick walls using modular bricks shall be considered as 200 mm and 100 mm respectively. In the event of use of traditional bricks of nominal size 230 mmx115mmx75mm with tolerance upto ±3 mm in each dimension, one brick and half brick walls shall be considered as 230 mm and 115 mm respectively.

7.2.1.3 Bricks shall be sound, hard, homogenous in texture, well burnt in kiln without being vitrified, hand/machine moulded, deep red, cherry or copper coloured, of regular shape and size & shall have sharp and square edges with smooth rectangular faces. The bricks shall be free from pores, cracks, flaws and nodules of free lime. Hand

moulded bricks shall be moulded with a frog and those made by extrusion process may not be provided with a frog. Bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 5N/sq.mm unless otherwise specified in the Items of work prepared by the Contractor.

7.2.1.4 The average water absorption shall not be more than 20 percent by weight upto class 12.5 and 15 percent by weight for higher classes. Bricks which do not conform to this requirement shall be rejected. Over or under burnt bricks are not acceptable for use in the works.

7.2.1.5 Sample bricks shall be submitted to the EMPLOYER for approval and bricks supplied shall conform to approved samples. If demanded by EMPLOYER, brick samples shall be got tested as per IS: 3495 by Contractor. Bricks rejected by EMPLOYER shall be removed from the site of works within 24 hours.

7.2.1.6 Mortar for brick masonry shall consist of cement and sand and shall be prepared as per IS: 2250. Mix shall be in the proportion of 1:5 for brickwork of thickness one brick or above and 1:4 for brickwork of thickness half brick or below, unless otherwise specified in the respective items of work prepared by the Contractor. Sand for masonry mortar shall conform to IS:218. The sand shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by EMPLOYER. If so directed by the EMPLOYER, sand shall be screened and washed till it satisfies the limits of deleterious materials.

7.2.1.7 For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry condition. Water shall then be added and mixing continued to give a uniform mix of required consistency. Mixing shall be done thoroughly in a mechanical mixer, unless hand mixing is specifically permitted by the EMPLOYER. The mortar thus mixed shall be used as soon as possible, preferably within 30 minutes from the time water is added to cement. Incase, the mortar has stiffened due to evaporation of water, this may be re-tempered by adding water as required to restore consistency, but this will be permitted only upto 30 minutes from the time of initial mixing of water to cement. Any mortar which is partially set shall be rejected and shall be removed forthwith from the site. Droppings of mortar shall not be re-used under any circumstances. The Contractor shall arrange for test on mortar samples if so directed by the EMPLOYER.

7.2.2 Workmanship

7.2.2.1 Workmanship of brick work shall conform to IS: 2212. All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. The cement mortar for brick masonry work shall be as specified in the respective item of work prepared by the Contractor. Brick work 200mm/230mm thick and over shall be laid in English Bond unless otherwise specified. 100mm/115mm thick brickwork shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be slightly pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Only full size bricks shall be used

for the works and cut bricks utilised only as closers to make up required wall length or for bonding. Bricks shall be laid with frogs on top.

7.2.2.2 All brickwork shall be plumb, square and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be levelled. The thickness of brick courses shall be kept uniform. In case of one brick thick or half brick thick wall, at least one face should be kept smooth and plane, even if the other is slightly rough due to variation in size of bricks. For walls of thickness greater than one brick both faces shall be kept smooth and plane. All interconnected brickwork shall be carried out at nearly one level so that there is uniform distribution of pressure on the supporting structure and no portion of the work shall be left more than one course lower than the adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed) at an angle not exceeding 45 deg. But in no case the level difference between adjoining walls shall exceed one metre. Brick work shall not be raised more than one metre per day.

7.2.2.3 Bricks shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 10mm/15mm by raking tools during the progress of work when the mortar is still green, so as to provide a proper key for the plastering/ pointing respectively to be done later. When plastering or pointing is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top.

7.2.2.4 During inclement weather conditions, newly built brick masonry works shall be protected by tarpaulin or other suitable covering to prevent mortar being washed away by rain.

7.2.2.5 Brickwork shall be kept constantly moist on all the faces for at least seven days after 24 hrs of laying. The arrangement for curing shall be got approved from the EMPLOYER.

7.2.2.6 Double scaffolding having two sets of vertical supports shall be provided to facilitate execution of the masonry works. The scaffolding shall be designed adequately considering all the dead, live and possible impact loads to ensure safety of the workmen, in accordance with the requirements stipulated in IS:2750 and IS:3696 (Part I). Scaffolding shall be properly maintained during the entire period of construction. Single scaffolding shall not be used on important works and will be permitted only in certain cases as decided by the EMPLOYER. Where single scaffolding is adopted, only minimum number of holes, by omitting a header shall be left in the masonry for supporting horizontal scaffolding poles. All holes in the masonry shall be carefully made good before plastering/pointing.

7.2.2.7 In the event of usage of traditional bricks of size 230 mm x115mm x75mm, the courses at the top of the plinth and sills as well as at the top of the wall just below the roof/floor slabs and at the top of the parapet shall be laid with bricks on edge.

7.2.2.8 All brickwork shall be built tightly against columns, floor slabs or other structural members.

7.2.2.9 To overcome the possibility of development of cracks in the brick masonry following measures shall be adopted.

7.2.2.10 For resting RCC slabs, the bearing surface of masonry wall shall be finished on top with 12 mm thick cement mortar 1:3 and provided with 2 layers of Kraft paper Grade 1 as per IS:1397 or 2 layers of 50 micron thick polyethylene sheets.

7.2.2.11 RCC/ steel beams resting on masonry wall shall be provided with reinforced concrete bed blocks of 50 mm thickness, projecting 50mm on either sides of the beam, duly finished on top with 2 layers of Kraft paper Grade 1 as per IS:1397 or 2 layers of 50 micron thick polyethylene sheets.

7.2.2.12 Steel wire fabric shall be provided at the junction of brick masonry and concrete before taking up plastering work.

7.2.2.13 Bricks for partition walls shall be stacked adjacent to the structural member to pre-deflect the structural member before the wall is taken up for execution. Further, the top most course of half or full brick walls abutting against either a deshuttered slab or beam shall be built only after any proposed masonry wall above the structural member is executed to cater for the deflection of the structural element.

7.2.2.14 Reinforced cement concrete transomes and mullions of dimensions as indicated in the construction Drawings to be prepared by the Contractor are generally required to be provided in the half brick partition walls.

7.2.2.15 Where the drawings prepared by the Contractor indicate that structural steel sections are to be encased in brickwork, the brickwork masonry shall be built closely against the steel section, ensuring a minimum of 20mm thick cement-sand mortar 1:4 over all the steel surfaces. Steel sections partly embedded in brickwork shall be provided with bituminous protective coating to the surfaces at the point of entry into the brick masonry.

7.2.2.15 Facing bricks of the type specified conforming to IS:2691 shall be laid in the positions indicated on the Drawings prepared by the Contractor and all facing brickwork shall be well bonded to the backing bricks/RCC surfaces. The level of execution of the facing brick work shall at any time be lower by at least 600 mm below the level of the backing brickwork.

7.2.2.16 Facing bricks shall be laid over 10 mm thick backing of cement mortar. The mortar mix, thickness of joint and the type of pointing to be carried out shall be as specified in the item of works prepared by the Contractor. The pattern of laying the bricks shall be as specifically indicated in the Drawings prepared by the Contractor. For facing brickwork, double scaffolding shall be used. Faced works shall be kept clean and free from damage, discoloration etc., at all times.

7.3 Uncoursed Random Rubble Masonry, in Foundation, Plinth and Superstructure

7.3.1 Materials

7.3.1.1 Stones for the works shall be of the specified variety which are hard, durable, fine grained and uniform in colour (for superstructure work) free from veins, flaws and other defects. Quality and work shall conform to the requirements specified in IS:1597 (Part-I). The percentage of water absorption shall not exceed 5 percent as per test conducted in accordance with IS:1124. The Contractor shall supply sample stones to the EMPLOYER for approval. Stones shall be laid with its grains horizontal so that the load transmitted is always perpendicular to the natural bed.

7.3.1.2 Cement-sand mortar for stone masonry works shall be in the proportion of 1:6. Materials and preparation of mortar shall be as specified in clause 7.2.1.

7.3.2 Workmanship

7.3.2.1 For All Works below ground level the masonry shall be random rubble uncoursed with ordinary quarry dressed stones for the hearting and selected quarry dressed stones for the facing.

7.3.2.2 For all works above ground level and in superstructure the masonry shall be random rubble uncoursed, well bonded, faced with hammer dressed stones with squared quoins at corners. The bushings on the face shall not be more than 40 mm on an exposed face and on the face to be plastered it shall not project by more than 12 mm nor shall it have depressions more than 10 mm from the average wall surface.

7.3.2.3 Face stones shall extend back sufficiently and bond well with the masonry. The depth of stone from the face of the wall inwards shall not be less than the height or breadth at the face. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three-fourths the thickness of wall nor less than 150 mm. The height of stone may be upto a maximum of 300 mm. Face stones or hearting stones shall not be less than 150 mm in any direction.

7.3.2.4 Chips and spalls shall be used wherever necessary to avoid thick mortar joints and to ensure that no hollow spaces are left in the masonry. The use of chips and spalls in the hearting shall not exceed 20 percent of the quantity of stone masonry. Spalls and chips shall not be used on the face of the wall and below hearting stones to bring them to the level of face stones.

7.3.2.5 The maximum thickness of joints shall not exceed 20 mm. All joints shall be completely filled with mortar. When plastering or pointing is not required to be done, the joints shall be struck flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of the work while the mortar is still green.

7.3.2.6 Through or bond stones shall be provided in walls upto 600 mm thick and in case of walls above 600 mm thickness, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous lime stone and sand stone, etc.) the bond stone shall extend about two-thirds into the wall and a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. Each bond stone or a set of bond stones shall be provided for every 0.5 sq.m of wall surface.

7.3.2.7 All stones shall be sufficiently wetted before laying to prevent absorption of water from the mortar. All connected walls in a structure shall be normally raised uniformly and regularly. However if any part of the masonry is required to be left behind, the wall shall be raked back (and not saw toothed) at an angle not exceeding 45deg. Masonry work shall not be raised by more than one metre per day.

7.3.2.8 Green work shall be protected from rain by suitable covering. Masonry work shall be kept constantly moist on all the faces for a minimum period of seven days for proper curing of the joints.

7.3.2.9 Type of scaffolding to be used shall be as specified in clause 7.2.2.

7.4 Coursed Rubble Masonry (First Sort) for Superstructure

7.4.1 Materials

7.4.1.1 The Material specification for the work shall be as per clause 7.3.1.

7.4.2 Workmanship

7.4.2.1 All Courses shall be laid truly horizontal and shall be of the same height in any course. The height of course shall not be less than 150 mm and not more than 300 mm. The width of stone shall not be less than its height.

7.4.2.2 Face stones shall tail into the work for not less than their height and atleast 1/3rd the number of stones shall tail into the work for a length not less than twice their height but not more than three-fourths the thickness of the wall whichever is smaller. These should be laid as headers and stretchers alternately to break joints by atleast 75 mm.

7.4.2.3 The face stones shall be squared on all joints and beds; the bed joints being hammer or chisel dressed true and square for at least 80 mm back from the face and the side joints for atleast 40 mm. The face of the stone shall be hammer dressed so that the bushing shall not be more than 40 mm on an exposed face and 10 mm on a face to be plastered. No portion of the dressed surface shall show a depth of gap more than 6 mm from a straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joints.

7.4.2.4 No spalls or pinnings shall be allowed on the face. All bed joints shall be horizontal and side joints shall be vertical and no joints shall be more than 10 mm in thickness. When plastering or pointing is not required to be done, the joints shall be struck

flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool, during the progress of the work while the mortar is still green.

7.4.2.5 Hearting shall consist of flat bedded stones carefully laid on their proper beds and solidly bedded in mortar. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10 percent of the quantity of the stone masonry. Care shall be taken so that no hollow spaces are left anywhere in the masonry.

7.4.2.6 The requirement regarding through or bond stones shall be as specified in clause 7.3.2 with the further stipulation that these shall be provided at 1.5 m to 1.8m apart clear in every course but staggered at alternate courses.

7.4.2.7 The quoins which shall be of the same height as the course in which they occur, shall not be less than 450 mm in any direction. Quoin stones shall be laid as stretchers and headers alternately. They shall be laid square on their beds, which shall be rough chisel dressed to a depth of at least 100 mm from the face. These stones shall have a minimum uniform chisel drafts of 25mm width at four edges, all the edges being in the same plane.

7.4.2.8 Type of scaffolding to be used shall be as per Clause 7.2.2. Requirements of execution of the work and curing shall be as stipulated in clause 7.3.2 .

7.5 Concrete Block Masonry

7.5.1 Materials

7.5.1.1 Masonry units of hollow and solid concrete blocks shall conform to the requirements of IS : 2185 (Part I).

7.5.1.2 Masonry units of hollow and solid light-weight concrete blocks shall conform to the requirements of IS : 2185 (Part 3).

7.5.1.3 Masonry units of autoclaved cellular concrete blocks shall conform to the requirements of IS:2185 (Part 3).

7.5.1.4 The height of the concrete masonry units shall not exceed either its length or six times its width.

7.5.1.5 The nominal dimensions of concrete block shall be as under.

a) Length 400, 500 or 600 mm
b) Height 100 or 200 mm
c) Width 100 to 300 mm in 50 mm increments

7.5.1.6 Half blocks shall be in lengths of 200, 250 or 300mm to correspond to the full length blocks.

7.5.1.7 Actual dimensions shall be 10mm short of the nominal dimensions.

7.5.1.8 The maximum variation in the length of the units shall not be more than ±5 mm and maximum variation in height or width of the units shall not be more than ± 3mm.

7.5.1.9 Concrete blocks shall be either hollow blocks with open or closed cavities or solid blocks.

7.5.1.10 Concrete blocks shall be sound, free of cracks, chipping or other defects which impair the strength or performance of the construction. Surface texture shall as specified. The faces of the units shall be flat and rectangular, opposite faces shall be parallel and all arises shall be square.

7.5.1.11 The bedding surfaces shall be at right angles to the faces of the block.

7.5.1.12 The concrete mix for the hollow and solid concrete blocks/light weight concrete blocks shall not be richer than one part of cement to six parts of combined aggregates by volume.

7.5.1.13 Concrete blocks shall be of approved manufacture, which satisfy the limitations in the values of water absorption, drying shrinkage and moisture movement, as specified for the type of block as per relevant IS code. Contractor shall furnish the test certificates and also supply the samples for the approval of EMPLOYER.

7.5.2 Workmanship

7.5.2.1 The type of the concrete block, thickness and grade based on the compressive strength for use in load bearing and/or non-load bearing walls shall be as specified. The minimum nominal thickness of non-load bearing internal walls shall be 100mm. The minimum nominal thickness of external panel walls in framed construction shall be 200 mm.

7.5.2.2 The workmanship shall generally conform to the requirements of IS:2572 for concrete block masonry, IS:6042 for light weight concrete block masonry and IS:6041 for autoclaved cellular concrete block masonry works.

7.5.2.3 From considerations of durability, generally concrete block masonry shall be used in superstructure works above the damp-proof course level.

7.5.2.4 Concrete blocks shall be embedded with a mortar which is relatively weaker than the mix of the blocks in order to avoid the formation of cracks. Cement mortar of proportion 1:6 shall be used for the works. Preparation of mortar shall be as specified in clause 7.2.1.

7.5.2.5 The thickness of both horizontal and vertical joints shall be 10mm. The first course shall be laid with greater care, ensuring that it is properly aligned, levelled and plumb since this will facilitate in laying succeding courses to obtain a straight and truly vertical wall. For the horizontal (bedding) joint, mortar shall be spread over the entire top surface of the block including front and rear shells as well as the webs to a uniform layer of 10mm. For vertical joints, the mortar shall be applied on the vertical edges of the front and rear shells of the blocks. The mortar may be applied

either to the unit already placed on the wall or on the edges of the succeeding unit when it is standing vertically and then placing it horizontally, well pressed against the previously laid unit to produce a compacted vertical joint. In case of two cell blocks with slight depression on the vertical sides these shall also be filled up with mortar to secure greater lateral rigidity. To assure satisfactory bond, mortar shall not be spread too far ahead of actual laying of the block as the mortar will stiffen and lose its plasticity Mortar while hardening shrinks slightly and thus pulls away from the edges of the block. The mortar shall be pressed against the units with a jointing tool after it has stiffened to effect intimate contact between the mortar and the unit to obtain a weather tight joint. The mortar shall be raked to a depth of 10mm as each course is laid to ensure good bond for the plaster.

7.5.2.6 Dimensional stability of hollow concrete blocks is greatly affected by variations of moisture content in the units. Only well dried blocks should be used for the construction. Blocks with moisture content more than 25% of maximum water absorption permissible shall not be used. The blocks should not be wetted before or during laying in the walls. Blocks should be laid dry except slightly moistening their surfaces on which mortar is to be applied to obviate absorption of water from the mortar.

7.5.2.7 As per the design requirements and to effectively control cracks in the masonry, RCC bound beams/studs, joint reinforcement shall be provided at suitable locations. Joint reinforcement shall be fabricated either from mild steel wires conforming to IS:280 or welded wire fabric/high strength deformed basis.

7.5.2.8 For jambs of doors, windows and openings, should concrete blocks shall be provided. If hollow units are used, the hollows shall be filled with concrete of mix 1:3:6. Hold fasts of doors/windows should be arranged so that they occur at block course level.

7.5.2.9 At intersection of walls, the courses shall laid up at the same time with a true masonry bond between atleast 50% of the concrete blocks. The sequence for construction of partition walls and treatment at the top of load bearing walls for the RCC slab shall be as detailed under clause 7.2 for the brick work.

7.5.2.10 Curing of the mortar joints shall be carried out for atleast 7 days. The walls should only be lightly moistened and shall not be allowed to become excessively wet.

7.5.2.11 Double scaffolding as per clause 7.2.2 shall be adopted for execution of block masonry work.

7.5.2.12 Cutting of the units shall be restricted to a minimum. All horizontal and vertical dimensions shall be in respectively, adopting modular co-ordination for walls, opening locations for doors, windows etc.

7.5.2.13 Concrete blocks shall be stored at site suitably to avoid any contact with moisture from the ground and covered to protect against wetting.

7.6 Damp - Proof Course

7.6.1 Materials and Workmanship

7.6.1.1 Where Specified, all the walls in a building shall be provided with damp-proof course cover plinth to prevent water from rising up the wall. The damp-proof course shall run without a break throughout the length of the wall, even under the door or other openings. Damp-proof course shall consist of 50 mm thick cement concrete of 1:2:4 nominal mix with approved water-proofing compound admixture conforming to IS: 2645 in proportion as directed by the manufacturer. Concrete shall be with 10 mm down graded coarse aggregates.

7.6.1.2 The surface of brick work/stone masonry work shall be levelled and prepared before laying the cement concrete. Side shuttering shall be properly fixed to ensure that slurry does not leak through and is also not disturbed during compaction. The upper and side surface shall be made rough to afford key to the masonry above and to the plaster.

7.6.1.3 Damp-proof course shall be cured properly for atleast seven days after which it shall be allowed to dry for taking up further work.

7.7 Miscellaneous Inserts, Bolts etc.

7.7.1 All the miscellaneous inserts such as bolts, pipes, plate embedments etc., shall be accurately installed in the building works at the correct location and levels, all as detailed in the construction Drawings to be prepared by the Contractor prepared by the Contractor. Contractor shall prepare and use templates for this purpose, if so directed by the EMPLOYER. In the event, of any of the inserts are improperly installed, Contractor shall make necessary arrangements to remove and reinstall at the correct locations/levels, all as directed by the EMPLOYER.

7.8 Wood Work for Doors, Windows, Ventilators & Partitions

7.8.1 Materials

7.8.1.1 Timber To be used shall be first class Teak wood as per IS:4021. Timber shall be of the best quality and well seasoned by a suitable process before being planed to the required sizes. The maximum permissible moisture content shall be from 10 to 16 percent for timber 50mm and above in thickness and 8 to 14 percent of timber less than 50mm in thickness for different regions of the country as stipulated in IS:287. Timber shall be close grained, of uniform colour and free from decay, fungal growth, boxed heart, pitch pockets or streaks on the exposed edges, borer holes, splits and cracks.

7.8.1.2 Flush door shutters of the solid core type with plywood face panels shall conform to IS:2202 (Part 1) and with particle board/hard board face panels shall conform to IS:2202 (Part 2).

7.8.1.3 Transparent sheet glass shall conform to the requirements of IS:2835. Wired and figured glass shall be as per IS:5437.

7.8.1.4 Builder's hardware for fittings and fixtures shall be of the best quality from approved manufacturers.

7.8.2 Workmanship

7.8.2.1 The workmanship and finish of wood work in doors, windows, ventilators and partitions shall be of a very high order. Contractor shall ensure that work is executed in a professional manner by skilled carpenters for good appearance, efficient and smooth operation of the shutters.

7.8.2.2 All works shall be executed as per the detailed Drawings prepared by the Contractor and/or as directed by the EMPLOYER.

7.8.2.3 All members of the door, window, and ventilator shall be straight without any warp or bow and shall have smooth well planed faces. The right angle shall be checked from the inside surfaces of the respective members of the frame. Frames shall have mortice and tenon joints which shall be treated with an approved adhesive and provided with metal or wood pins. The vertical members of the door frame shall project 50 mm below the finished floor level. The finished dimension of frames shall be rebated on the solid for keying with the plaster and for receiving the shutters. The depth of rebate for housing the shutter shall be 15 mm. The size of the frames shall be as specified in the respective items of work prepared by the Contractor. The workmanship shall generally conform to the requirements specified in IS:4021.

7.8.2.4 The face of the frames abutting the masonry or concrete shall be provided with a coat of coal tar.

7.8.2.5 Three hold fasts using 25 mm x 6 mm mild steel flats 225 mm long with split ends shall be fixed on each side of door and window frames, one at the centre and the other two at 300 mm from the top and bottom of the frame. For window and ventilator frames less than 1 m in height, two hold fasts on each side shall be fixed at quarter points.

7.8.2.6 Timber panelled shutters for doors, windows and ventilators shall be constructed in the form of framework of stiles and rails with panel insertion. The panels shall be fixed by either providing grooves in the stiles and rails or by beading. Glazing bars shall be as detailed in the Drawings prepared by the Contractor. The stiles and rails shall be joined by mortice and tenon joints at right angles. All members of the shutter shall be straight without any warp or bow and shall have smooth, well planed faces at right angles to each other. The right angle for the shutter shall be checked by measuring the diagonals and the difference shall not be more than ± 3 mm. Timber panels made from more than one piece shall be jointed with a continuous tongued and grooved joint, glued together and reinforced with metal dowels. The workmanship shall generally conform to the requirements specified in IS:1003 (Parts 1 & 2). The thickness of the shutter, width/thickness of the

stiles/rails/panel type shall be as specified. Marine plywood panels conforming to IS:710 shall be used for doors where specified.

7.8.2.7 Details of the wooden flush door shutters, solid core type with specific requirement of the thickness, core, face panels, viewing glazed panel, venetian louvre opening, teak wood lipping etc. shall be as specified. Panels of shutter shall be of marine plywood conforming to IS:710. Flush door shutters shall be from reputed manufacturers and Contractor shall submit test results as per IS:4020, if so desired by the EMPLOYER.

7.8.2.8 Glazing of door, window, ventilator and partitions shall be with either flat transparent sheet glass, wired or figured glass. Transparent sheet glass shall be of 'B' quality as per IS:2835.The thickness and type of glazing to be provided shall be as specified.

7.8.2.9 The material of the fittings and fixtures either of chromium plated steel, cast brass, copper oxidised or anodised aluminum shall be as specified. The number, size and type of the fittings and fixtures shall be as specified.

7.8.2.10 Woodwork shall not be provided with the finishes of painting/varnishing etc. unless it has been approved by the EMPLOYER. The type of finish and the number of coats shall be as stipulated in the respective items of work prepared by the Contractor. Preparation of the wood surfaces and application of the finishes shall be in accordance with clause 7.32.

7.8.2.11 Wooden hand railing and architrave's shall be of the size and shape with the fixing arrangement as indicated in the Drawings prepared by the Contractor.

7.8.2.12 The framework of the partitions with mullions and transoms shall be with the sections of dimensions as specified. Panels of double/single glazing/plywood shall be fixed as per details specified. Partitions shall be fixed rigidly between the floor and structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the construction Drawings prepared by the Contractor.

7.8.2.13 Any carpentry work which show defects due to inadequate seasoning of the timber or bad workmanship shall be removed and replaced by Contractor with work as per Specifications.

7.9 Steel Doors, Windows and Ventilators

7.9.1 Materials

7.9.1.1 Hot rolled steel sections for the fabrication of steel doors, windows and ventilators shall conform to IS: 7452, which are suitable for, single glazing.

7.9.1.2 Pressed steel door frames for steel flush doors shall be out of 1.25mm thick mild steel sheets of profiles as per IS : 4351.

7.9.1.3 Transparent sheet glass shall conform to the requirements of IS : 2835. Wired and figured glass shall be as per IS : 5437.

7.9.1.4 Builder's hardware of fittings and fixtures shall be of the best quality from the approved manufacturers.

7.9.2 Workmanship

7.9.2.1 All steel doors, windows and ventilators shall be of the type as specified in the respective items of work prepared by the Contractor and of sizes as indicated in the Drawings prepared by the Contractor prepared by the Contractor. Steel doors, windows and ventilators shall conform to the requirements as stipulated in IS : 1038. Steel windows shall conform to IS : 1361, if so specified.

7.9.2.2 Doors, windows and ventilators shall be of an approved manufacture. Fabrication of the unit shall be with rolled section, cut to correct lengths and metered. Corners shall be welded to form a solid fused welded joint conforming to the requirements of IS : 1038. Tolerance in overall dimensions shall be within ±1.5mm. The frames and shutters shall be free from wrap or buckle and shall be square and truly plain. All welds shall be dressed flush on exposed and contact surfaces. Punching of holes, slots and other provisions to install fittings and fixtures later shall be made at the correct locations as per the requirements. Samples of the units shall be got approved by the EMPLOYER before further manufacture/purchase by the Contractor.

7.9.2.3 Type and details of shutters, hinges, glazing bar requirement, couplings, locking arrangement, fittings and fixtures shall be as described in the respective items of work and / or as shown in the Drawings prepared by the Contractor for single or composite units.

7.9.2.4 For windows with fly proof mesh as per the item of work prepared by the Contractor, rotor operator arrangement, for the operation of the glazed shutters from the inside shall be provided.

7.9.2.5 Pressed steel door frames shall be provided with fixing lugs at each jamb, hinges, lock-strike plate, mortar guards, angle threshold, shock-absorbers of rubber or similar material as per the requirements of IS : 4351. Pressed steel doorframes shall be fixed as `built-in' as the masonry work proceeds. After placing it plumb at the specified location, masonry walls shall be built up solid on either side and each course grouted with mortar to ensure solid contact with the doorframe, without leaving any voids. Temporary struts across the width shall be fixed, during erection to prevent bow/sag of the frame.

7.9.2.6 Door shutters of flush welded construction shall be 45mm thick, fabricated with two outer skills of 1.25mm thick steel sheets, 1mm thick steel sheet stiffeners and steel channels on all four edges. Double shutters shall have meeting stile edge beveled or rebated. Provision of glazed viewing panel, louvers shall be made as per the items of works and/or Drawings prepared by the Contractor. Shutters shall be suitably reinforced for lock and other surface hardware and to prevent sagging/twisting.

Single sheet steel door shutters shall be fabricated out of 1.25mm thick steel sheets, mild steel angles and stiffeners as per the Drawings prepared by the Contractor.

7.9.2.7 Doors, windows and ventilators shall be fixed into the prepared openings. They shall not be 'built-in' as the masonry work proceeds, to avoid distortion and damage of the units. The dimensions of the masonry opening shall have 10mm clearance around the overall dimensions of the frame for this purpose. Any support of scaffolding members on the frames/glazing bars is prohibited.

7.9.2.8 Glazing of the units shall be either with flat transparent glass or wired / figured glass of the thickness as specified in the items of works prepared by the Contractor. All glass panels shall have properly squared corner and straight edges. Glazing shall be provided on the outside of the frames.

7.9.2.9 Fixing of the glazing shall be either with spring glazing clips and putty conforming to IS:419 or with metal beads. Pre-formed PVC or rubber gaskets shall be provided for fixing the beads with the concealed screws. The type of fixing the glazing shall be as indicated in the items of work and/or in Drawings prepared by the Contractor.

7.9.2.10 Steel doors, windows and ventilators shall be provided with finish of either painting as specified or shall be hot dip galvanised with thickness of the zinc coating as stipulated all as described in the respective items of works prepared by the Contractor.

7.9.2.11 The material of the Builders hardware of fittings and fixtures of chromium plated steel, cast brass, brass copper oxidised or anodised aluminium shall be as specified in the items of works prepared by the Contractor. The number , size and type of fittings and fixtures shall be as in the Drawings /items of works prepared by the Contractor.

7.9.2.12 Installation of the units with fixing lugs, screws, mastic caulking compound at the specified locations shall generally conform to the requirements of IS:1081. Necessary holes etc required for fixing shall be made by the Contractor and made good after installation. Workmanship expected is of a high order for efficient and smooth operation of the units.

7.10 Aluminum Doors, Windows, Ventilators & Partitions

7.10.1 Materials

7.10.1.1 Aluminum alloy used in the manufacture of extruded sections for the fabrication of doors, windows, ventilators shall conform to designation HE9-WP of IS:733.

7.10.1.2 Transparent sheet glass shall conform to the requirements of IS:2835. Wired and figured glass shall be as per IS:5437.

7.10.1.3 Builder's hardware of fittings & fixtures shall be of the best quality from approved manufacturers.

7.10.2 Workmanship

7.10.2.1 All aluminum doors, windows, ventilators and partitions shall be of the type and size as specified. The doors, windows, ventilators shall conform to the requirements of IS:1948. Aluminum windows, shall conform to IS:1949, if so specified.

7.10.2.2 All aluminum units shall be supplied with anodized finish. The minimum anodic film thickness shall be 0.015 mm.

7.10.2.3 Doors, windows and ventilators shall be of an approved manufacture. Fabrication of the units shall be with the extruded sections, cut to correct lengths, mitred and welded at the corners to a true right angle conforming to the requirements of IS:1948. Tolerance in overall dimensions shall be within ± 1.5mm. The frames and shutters shall be free from warp or buckle and shall be square and truly plane. Punching of holes, slots and other provisions to install fittings or fixtures later shall be made at the correct locations, as per the requirements.

7.10.2.4 Aluminium swing type doors, aluminum sliding windows, partitions shall be as specified.

7.10.2.5 IS:1948 and IS:1949 referred to incorporates the sizes, shapes, thicknesses and weight per running metre of extruded sections for the various components of the units. However, new sizes, shapes, thicknesses with modifications to suit snap-fit glazing clips etc. are being continuously being added by various leading manufacturers of extruded sections, which are available in the market. As such, the sections of the various components of the unit proposed by the Contractor, will be reviewed by the EMPLOYER and will be accepted only if they are equal to or marginally more than that given in the codes/as specified.

7.10.2.6 The framework of the partitions with mullions and transomes shall be with anodised aluminium box sections. Anodised aluminium box sections shall be in-filled with timber of class 3 (silver oak or any other equivalent) as per IS:4021. Panels of double/single glazing/plywood shall be fixed as per details indicated in the Drawings to be prepared by the Contractor. Partitions shall be fixed rigidly between the floor and the structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the construction Drawings to be prepared by the Contractor.

7.10.2.7 Specific provisions as stipulated for steel doors, windows, ventilators under clause 7.9.2 shall also be applicable for this item work. Glazing beads shall be of the snap-fit type suitable for the thickness of glazing proposed as indicated in the items of works prepared by the Contractor. A layer of clear transparent lacquer shall be applied on aluminium sections to protect them from damage during installation. This lacquer coating shall be removed after the installation is completed.

7.11 Steel Rolling Shutters

7.11.1 Materials and Workmanship

7.11.1.1 Rolling shutters shall be of an approved manufacture, conforming to the requirements specified in IS:6248.

7.11.1.2 The type of rolling shutter shall be self coiling type (manual) for clear areas upto 12 sq.m, gear operated type (mechanical) for clear areas upto 35 sq.m and electrically operated type for areas upto 50 sq.m. Mechanical type of rolling shutters shall be suitable for operation from both inside and outside with the crank handle or chain gear operating mechanism duly considering the size of wall/column. Electrical type of rolling shutter shall also be provided with a facility for emergency mechanical operation.

7.11.1.3 Rolling shutters shall be supplied duly considering the type, specified clear width/height of the opening and the location of fixing as indicated in the Drawings prepared by the Contractor.

7.11.1.4 Shutters shall be built up of interlocking laths 75 mm width between rolling centres formed from cold rolled steel strips. The thickness of the steel strip shall not be less than 0.90 mm for shutters upto 3.50 m width and not less than 1.20 mm for shutters above 3.50 m width. Each lath section shall be continuous single piece without any welded joint.

7.11.1.5 The guide channels out of mild steel sheets of thickness not less than 3.15 mm shall be of either rolled, pressed or built up construction. The channel shall be of size as stipulated in IS:6248 for various clear widths of the shutters.

7.11.1.6 Hood covers shall be of mild steel sheets not less than 0.90 mm thick and of approved shape.

7.11.1.7 Rolling shutters shall be provided with a central hasp and staple safety device in addition to one pair of lever locks and sliding locks at the ends.

7.11.1.8 All component parts of the steel rolling shutter (excepting springs and insides of guide channels) shall be provided with one coat of zinc chrome primer conformity to IS:2074 at the shop before supply. These surfaces shall be given an additional coat of primer after erection at the site along with the number of coats and type of finish paint as specified in the respective items of works prepared by the Contractor. Painting shall be carried out as per clause 7.33.

7.11.1.9 In case of galvanised rolling shutter, the lath sections, guides, lock plate, bracket plates, suspension shaft and the hood cover shall be hot dip galvanised with a zinc coating containing not less than 97.5 percent pure zinc. The weight of the zinc coating shall be atleast 610gms/sq.m.

7.11.1.10 Guide channels shall be installed truly plumb at the specified location. Bracket plate shall be rigidly fixed with necessary bolts and holdfasts. Workmanship of erection shall ensure strength and rigidity of rolling shutter for trouble free and smooth operation.

7.12 Rubble Sub-Base

7.12.1 Materials

7.12.1.1 Stones used for rubble packing under floors on grade, foundations etc., shall be clean, hard, durable rock free from veins, flaws, laminations, weathering and other defects. Stones shall generally conform to the requirements stipulated in IS: 1597 (Part I).

7.12.1.2 Stones shall be as regular as can be obtained from quarries. Stones shall be of height equal to the thickness of the packing proposed with a tolerance of $\pm$ 10 mm. Stones shall not have a base area less than 250 sq cm nor more than 500 sq.cm, and the smallest dimension of any stone shall not be less than half the largest dimension. The quality and size of stones shall be subject to the approval of the EMPLOYER.

7.12.2 Workmanship

7.12.2.1 Stones shall be hand packed carefully and laid with their largest base downwards resting flat on the prepared sub-grade and with their height equal to the thickness of the packing. Stones shall be laid breaking joints and in close contact with each other. All interstices between the stones shall be wedged-in by small stones of suitable size, well driven in by crow bars and hammers to ensure tight packing and complete filling-in of the interstices. The wedging shall be carried out simultaneously with the placing in position of rubble packing and shall not lag behind. After this, any interstices between the smaller wedged stones shall be infilled with clean hard sand by brooming so as to fill the joints completely.

7.12.2.2 The laid rubble packing shall be sprinkled with water and compacted by using suitable rammers.

7.13 Base Concrete

7.13.1 The thickness and grade of concrete and reinforcement shall be as specified in items of works prepared by the contractor.

7.13.2 Before placing the blinding concrete, the sub-base of rubble packing shall be properly wetted and rammed. Concrete for the base shall then be deposited between the forms, thoroughly tamped and the surface finished level with the top edges of the forms. Two or three hours after the concrete has been laid in position, the surface shall be roughened using steel wire brush to remove any scum or laitance and swept clean so that the coarse aggregates are exposed. The surface of the base concrete shall be left rough to provide adequate bond for the floor finish to be provided later.

7.14 Terrazzo and Plain Cement Tiling Work

7.14.1 Materials

7.14.1.1 Terrazzo tiles and cement tiles shall generally conform in all respects to standards stipulated in IS:1237. Tiles shall be of the best quality manufactured adopting hydraulic pressure of not less than 14N/mm^2.

7.14.1.2 The type, quality, size, thickness colour etc, of the tiles for flooring/dado/skirting shall be as specified.

7.14.1.3 The aggregates for terrazzo topping shall consist of marble chips which are hard, sound and dense. Cement to be used shall be either ordinary portland cement or white cement with or without colouring pigment. The binder mix shall be with 3 parts of cement to 1 part of marble powder by weight. The proportion of cement shall be inclusive of any pigments. For every one part of cement-marble powder binder mix, the proportion of aggregates shall be 1.75 parts by volume, if the chips are between 1mm to 6mm and 1.50 parts by volume if the chips are between 6mm to 25mm.

7.14.1.4 The minimum thickness of wearing layer of terrazzo tiles shall be 5mm for tiles with chips of size varying from 1mm upto 6mm or from 1mm upto 12mm. This shall be 6mm for tiles with chips varying from 1mm upto 25mm. The minimum thickness of wearing layer of cement/coloured cement tiles shall be 5mm. This shall be 6mm for heavy duty tiles. Pigment used in the wearing layer shall not exceed 10 percent of the weight of cement used in the mix.

7.14.2 Workmanship

7.14.2.1 Laying and finishing of tiles shall conform to the requirements of workmanship stipulated in IS:1443.

7.14.2.2 Tiling work shall be commenced only after the door and window frames are fixed and plastering of the walls/ ceiling is completed. Wall plastering shall not be carried out upto about 50mm above the level of proposed skirting/dado.

7.14.2.3 The base concrete shall be finished to a reasonably plane surface about 40 to 45mm below the level of finished floor. Before the tiling work is taken up, the base concrete or structural slab shall be cleaned of all loose materials, mortar droppings, dirt, laitance etc. using steel wire brush and well wetted without allowing any water pools on the surface.

7.14.2.4 A layer of 25mm average thickness of cement mortar consisting of one part of cement to 6 parts of sand shall be provided as bedding for the tiles over the base concrete. The thickness of bedding mortar shall not be less than 10mm at any place. The quantity of water to be added for the mortar shall be just adequate to obtain the workability for laying. Sand for the mortar shall conform to IS:2116 and shall have minimum fineness modulus of 1.5. The surface shall be left rough to provide a

good bond for the tiles. The bedding shall be allowed to harden for a day before laying of the tiles.

7.14.2.5 Neat cement slurry using 4.4 kg of cement per sq.m of floor area shall be spread over the hardened mortar bedding over such an area at a time as would accommodate about 20 tiles. Tiles shall be fixed in this slurry one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be in straight lines and shall normally be 1.5mm wide. On completion of laying of the tiles in a room, all the joints shall be cleaned and washed fairly deep with a stiff broom/wire brush to a minimum depth of 5mm. The day after the tiles have been laid, the joints shall be filled with cement grout of the same shade as the colour of the matrix of the tile. For this purpose white cement or grey cement with or without pigments shall be used. The flooring should be kept moist and left undisturbed for 7 days for the bedding/joints to set properly. Heavy traffic shall not be allowed on the floor for atleast 14 days after fixing of the tiles.

7.14.2.6 About a week after laying the tiles, each and every tile shall be lightly tapped with a small wooden mallet to find out if it gives a hollow sound; if it does, such tiles along with any other cracked or broken tiles shall be removed and replaced with new tiles to proper line and level. The same procedure shall be followed again after grinding the tiles and all damaged tiles replaced, properly jointed and finished to match. For the purpose of ensuring that such replaced tiles match with those laid earlier, it is necessary that the Contractor shall procure sufficient quantity of extra tiles to meet this contingency.

7.14.2.7 Wherever a full tile cannot be provided, tiles shall be cut to size and fixed. Floor tiles adjoining the wall shall go about 10mm under the plaster, skirting or dado.

7.14.2.8 Tile skirting and dado work shall be executed only after laying tiles on the floor. For dado and skirting work, the vertical wall surface shall be thoroughly cleaned and wetted. Thereafter it shall be evenly and uniformly covered with 10mm thick backing of 1:4 cement sand mortar. For this work the tiles as obtained from the factory shall be of the size required and practically full polished. The back of each tile to be fixed shall be covered with a thin layer of neat cement paste and the tile shall then be gently tapped against the wall with a wooden mallet. Fixing shall be done from the bottom of the wall upwards. The joints shall be in straight lines and shall normally be 1.5mm wide. Any difference in the thickness of the tiles shall be evened out in the backing mortar or cement paste so that the tile faces are in conformity & truly plumb. Tiles for use at the corners shall be suitably cut with bevelled edges to obtain a neat and true joint. After the work has set, hand polishing with carborundum stones shall be done so that the surface matches with the floor finish.

7.14.2.9 Wall plastering of the strip left out above the level of skirting/dado shall be taken up after the tiles are fixed.

7.14.2.10 Chequered terrazzo tiles for flooring and for stair treads shall be delivered to site after the first machine grinding.

7.14.2.11 Machine grinding and polishing shall be commenced only after a lapse of 14 days of laying. The sequence and three numbers of machine grinding operations, usage of the type of carborundum stones, filling up of pin holes, watering etc. shall be carried out all as specified in IS:1443.

7.14.2.12 Tiles shall be laid to the levels specified. Where large areas are to be tiled the level of the central portion shall be kept 10mm higher than that at the walls to overcome optical illusion of a depression in the central portion. Localised deviation of ±3mm in any 3m length is acceptable in a nominally flat floor.

7.15 In-Situ Terrazzo Work

7.15.1 Materials

7.15.1.1 The requirements of marble aggregates for terrazzo topping shall be as per clause 7.14.1.

7.15.1.2 Cement shall first be mixed with the marble powder in dry state. The mix thus obtained shall be mixed with the aggregates in the specified proportions. Care shall be taken not to get the materials into a heap which results in the coarsest chips falling to the edges and cement working to the centre at the bottom. Materials shall be kept, as far as possible, in an even layer during mixing. After the materials have been thoroughly mixed in the dry state, water shall be added, just adequate to obtain plastic consistency for the desired workability for laying. The mix shall be used in the works within 30 minutes of the addition of water to the cement.

7.15.2 Workmanship

7.15.2.1 The thickness, type, quality, size and colour of chips etc. for the in-situ terrazzo finish for flooring/dado/ skirting shall be as specified in the respective items of works prepared by the Contractor. Laying and finishing of in-situ work shall conform to the requirements of workmanship stipulated in IS: 2114.

7.15.2.2 In-situ terrazzo finish shall be laid over hardened concrete base. The finish layer consists of an under layer and terrazzo topping. The underlayer shall be of cement concrete of mix 1:2:4 using 10mm down graded coarse aggregates. The combined thickness of under layer and topping shall not be less than 30 mm for flooring and 20mm for dado/skirting work.

7.15.2.3 The minimum thickness of topping shall be 6mm if chips used are between 1mm to 4mm, 9mm if chips are between 4mm to 7mm and 12mm if chips are between 7mm to 10mm. If chips larger than 10mm size are used, the minimum thickness shall be one and one third the maximum size of chips.

7.15.2.4 Both the underlayer and later the topping shall be divided into panels not exceeding 2 sq.m for laying so as to reduce the possibility of development of cracks. The longer dimension of any panel shall not exceed 2m. Dividing strips shall be used to

separate the panels. When the dividing strips are not provided, the bays shall be laid alternately, allowing an interval of atleast 24 hours between laying adjacent bays.

7.15.2.5 Dividing strips shall be either of aluminium, brass or other material as indicated in the items of works prepared by the Contractor. Aluminum strips should have a protective coating of bitumen. The thickness of the strips shall be not less than 1.5mm and width not less than 25mm for flooring work.

7.15.2.6 Concrete base shall be finished to a reasonably plane surface to a level below the finished floor elevation equal to the specified thickness of terrazzo finish. Before spreading the unde rlayer, the base concrete surface shall be cleaned of all loose materials, mortar droppings, dirt, laitance etc. and well wetted without allowing any water pools on the surface. Dividing strips or screed strips, if dividing strips are not provided shall be fixed on the base and levelled to the correct height to suit the thickness of the finish. Just before spreading the under layer the surface shall be smeared with cement slurry at 2.75 Kg/sq.m. Over this slurry, the under layer shall be spread and levelled with a screeding board. The top surface shall be left rough to provide a good bond for the terrazzo topping.

7.15.2.7 Terrazzo topping shall be laid while the under layer is still plastic and normally between 18 to 24 hours after the under layer is laid. Cement slurry of the same colour as the topping shall be brushed on the surface immediately before laying is commenced. The terrazzo mix shall be laid to a uniform thickness and compacted thoroughly by tamping and with a minimum of troweling. Straight edge and steel floats shall be used to bring the surface true to the required level in such a manner that the maximum amount of marble chips come up and spread uniformly all over the surface.

7.15.2.8 The surface shall be left dry for air-curing for a period of 12 to 18 hours. Thereafter it shall be cured by allowing water to stand in pools for a period of not less than 4 days.

7.15.2.9 Machine grinding and polishing shall be commenced only after a lapse of 7 days from the time of completion of laying. The sequence and four numbers of machine grinding operations, usage of the type of carborundum stones, filling up of pinholes, wet curing, watering etc shall be carried out all as specified in IS: 2114.

7.16 Shahabad / Tandur/ Kota Stone Slab work

7.16.1 Materials

7.16.1.1 The slabs shall be of approved selected quality, hard, sound, dense and homogenous in texture, free from cracks, decay, weathering and flaws. The percentage of water absorption shall not exceed 5 percent as per test conducted in accordance with IS : 1124.

7.16.1.2 The slabs shall be hand or machine cut to the required thickness. Tolerance in thickness for dimensions of tile more than 100mm shall be ±5mm. This shall be ±2mm on dimensions less than 100mm.

7.16.1.3 Slabs shall be supplied to the specified size with machine cut edges or fine chisel dressed to the full depth. All angles and edges of the slabs shall be true and square, free from any chipping giving a plane surface. Slabs shall have the top surface machine polished (first grinding) before being brought to site. The slabs shall be washed clean before laying.

7.16.2 Workmanship

7.16.2.1 The type, size, thickness and colour/shade etc. of the slabs for flooring/dado/skirting shall be as specified in the respective items of works prepared by the Contractor.

7.16.2.2 Preparation of the concrete base, laying and curing shall be as per clause 7.14.2.

7.16.2.3 Dado / skirting work shall be as per clause 7.14.2. The thickness of the slabs for dado/skirting work shall not be more than 25mm. Slabs shall be so placed that the back surface is at a distance of 12mm. If necessary, slabs shall be held in position temporarily by suitable method. After checking for verticality, the gap shall be filled and packed with cement sand mortar of proportion 1:3. After the mortar has acquired sufficient strength, the temporary arrangement holding the slab shall be removed.

7.16.2.4 Grinding and polishing shall be as per clause 7.14.2 except that first grinding with coarse grade carborundum shall not be done and cement slurry with or without pigment shall not applied before polishing.

7.17 Carborundum Tile Finish

7.17.1 Materials

7.17.1.1 Carborundum tiles shall generally conform in all respects to the standards stipulated in IS:1237 for heavy duty tiles. Tiles shall be of the best quality manufactured adopting hydraulic pressure of not less than 14 N/mm^2.

7.17.1.2 The topping shall be uniform and of thickness not less than 6mm. The quantity of carborundum grit shall be not less than 1.35 kg/sq.m used with cement with or without pigment. The carborundum grit shall pass through 1.18mm mesh and shall be retained on 0.60 mm mesh.

7.17.2 Workmanship

7.17.2.1 Requirements as detailed for terrazzo/cement tile finish under clause 7.14.2 shall be applicable for carborundum tile flooring.

7.18 Glazed Tile Finish

7.18.1 Materials

7.18.1.1 Glazed earthenware tiles shall conform to the requirements of IS: 777. Tiles shall be of the best quality from an approved manufacturer. The tiles shall be flat, true to

shape and free from flaws such as crazing, blisters, pinholes, specks or welts. Edges and underside of the tiles shall be free from glaze and shall have ribs or indentations for a better anchorage with the bedding mortar. Dimensional tolerances shall be as specified in IS: 777.

7.18.2 Workmanship

7.18.2.1 The total thickness of glazed tile finish including the bedding mortar shall be 20 mm in flooring/dado/skirting. The minimum thickness of bedding mortar shall be 12mm for flooring and 10mm for dado/skirting work.

7.18.2.2 The bedding mortar shall consist of 1 part of cement to 3 parts of sand mixed with just sufficient water to obtain proper consistency for laying. Sand for the mortar shall conform to IS: 2116 and shall have minimum fineness modulus of 1.5.

7.18.2.3 Tiles shall be soaked in water for about 10 minutes just before laying. Where full size tiles cannot be fixed, tiles shall be cut to the required size using special cutting device and the edges rubbed smooth to ensure straight and true joints.

7.18.2.4 Coloured tiles with or without designs shall be uniform and shall be preferably procured from the same batch of manufacture to avoid any differences in the shade.

7.18.2.5 Tiles for the flooring shall be laid over hardened concrete base. The surface of the concrete base shall be cleaned of all loose materials, mortar droppings etc well wetted without allowing any water pools on the surface. The bedding mortar shall then be laid evenly over the surface, tamped to the desired level and allowed to harden for a day. The top surface shall be left rough to provide a good bond for the tiles. For skirting and dado work, the backing mortar shall be roughened using a wire brush.

7.18.2.6 Neat cement slurry using 3.3 kg cement per sq.m of floor area shall be spread over the hardened mortar bed over such an area as would accommodate about 20 tiles. Tiles shall be fixed in this slurry one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. For skirting and dado work, the back of the tiles shall be smeared with cement slurry for setting on the backing mortar. Fixing of tiles shall be done from the bottom of the wall upwards. The joints shall be in perfect straight lines and as thin as possible but shall not be more than 1mm wide. The surface shall be checked frequently to ensure correct level/required slope. Floor tiles near the walls shall enter skirting/dado to a minimum depth of 10mm. Tiles shall not sound hollow when tapped.

7.18.2.7 All the joints shall be cleaned of grey cement with wire brush to a depth of at least 3mm and all dust, loose mortar etc. shall be removed. White cement with or without pigment shall then be used for flush pointing the joints. Curing shall then be carried out for a minimum period of 7 days for the bedding and joints to set properly. The surface shall then be cleaned using a suitable detergent, fully washed and wiped dry.

7.18.2.8 Specials consisting of coves, internal and external angles, cornices, beads and their corner pieces shall be of thickness not less than the tiles with which they are used.

7.19 In-Situ Cement Concrete Floor Topping

7.19.1 Materials

7.19.1.1 The mix proportion for the in-situ concrete floor topping shall be 1:2.5:3.5 (one part cement : two and half parts sand : three and half parts coarse aggregates) by volume unless otherwise specified.

7.19.1.2 The aggregates shall conform for the requirements of IS:383.

7.19.1.3 Coarse aggregates shall have high hardness surface texture and shall consist of crushed rock of granite, basalt, trap or quartzite. The aggregate crushing valve shall not exceed 30 percent. The grading of the aggregates of size 12.5mm and below shall be as per IS:2571.

7.19.1.4 Grading of the sand shall be within the limits indicated in IS:2571.

7.19.2 Workmanship

7.19.2.1 The thickness of the floor topping shall be as specified in the items of work prepared by the Contractor. The minimum thickness of the floor topping shall be 25mm.

7.19.2.2 Preparation of base concrete/structural slab before laying the topping shall be as per clause 7.13. The surface shall be rough to provide adequate bond for the topping.

7.19.2.3 Mixing of concrete shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the EMPLOYER. The concrete shall be as stiff as possible and the amount of water added shall be the minimum necessary to give just sufficient plasticity for laying and compacting. The mix shall be used in the work within 30 minutes of the addition of water for its preparation.

7.19.2.4 Floor finish shall be laid in suitable panels to reduce the risk of cracking. No dimension of a panel shall exceed 2 meters and the length of a panel shall not exceed one and a half times its breadth. Topping shall be laid in alternate panels, the intermediate panels being cast after a gap of at least one day. Construction joints shall be plain vertical butt joints.

7.19.2.5 Screed strips shall be fixed dividing the area into suitable panels. Immediately before depositing the concrete topping, neat cement slurry at 2.75 kg/sq.m of area shall be thoroughly brushed into the prepared surface. Topping shall then be laid, very thoroughly tamped, struck off level and floated with wooden float. The surface shall then be tested with a straight edge and mason's spirit level to detect any inequalities and these shall be made good immediately.

7.19.2.6 Finishing of the surface by troweling shall be spread over a period of one to six hours depending upon the temperature and atmospheric conditions. The surface shall be trowelled 3 times at intervals so as to produce a smooth uniform and hard

surface. Immediately after laying, the first trowelling just sufficient to give a level surface shall be carried out avoiding excessive trowelling at this stage. The surface shall be re- trowelled after sometime to close any pores and to scrap off excess water or laitance, which shall not be trowelled back into the topping. Final trowelling shall be done well before the concrete has become too hard but at a time when considerable pressure is required to make any impression on the surface. Sprinkling of dry cement or cement-sand mixture for absorbing moisture shall not be permitted.

7.19.2.7 Immediately after the surface is finished, it shall be protected suitably from rapid drying due to wind/ sunlight. After the surface has hardened sufficiently to prevent any damage to it, the topping shall be kept continuously moist for a minimum period of 10 days.

7.19.2.8 It is preferable to lay the topping on hardened base concrete, as against being laid monolithically with a lesser thickness, since proper levels and slopes with close surface tolerances is achievable in practice, owing to its greater thickness. Further, as this would be laid after all other building operations are over, there will be no risk of any damages or discoloration to the floor finish which are difficult to repair satisfactorily.

7.20 In-Situ Granolithic Concrete Floor Topping

7.20.1 Materials and Workmanship

7.20.1.1 The Requirements of materials and workmanship shall be all as per clause 7.19 for in-situ cement concrete floor topping except that the mix proportion of the concrete shall be 1:1:2 (cement: sand : coarse aggregates) by volume.

7.20.1.2 The minimum thickness of granolithic floor topping on hardened concrete base shall be 40mm.

7.21 Floor Hardener Topping

7.21.1 Materials & Workmanship

7.21.1.1 Floor Hardener topping shall be provided either as integrally finished over the structural slab/grade slab or laid monolithically with the concrete/granolithic floor finish on top of hardened concrete base.

7.21.1.2 Floor hardener of the metallic or non-metallic type suitable for the performance of normal / medium/ heavy duty function of the floor, the quantum of ingredients and the thickness of topping shall be as specified in the respective items of work prepared by the Contractor.

7.21.1.3 For monolithic application with the floor finish/slab the thickness of the layer shall be 15mm. The topping shall be laid within 2 to 3 hours after concrete is laid when it is still plastic but stiffened enough for the workmen to tread over it by placing planks. The surface of the concrete layer shall be kept rough for providing adequate bond for the topping. Laitance shall be removed before placing the topping. The

topping shall be screeded and thoroughly compacted to the finished level. Trowelling to a smooth finish shall be carried out as per clause 7.19.2. After the surface has hardened sufficiently, it shall be kept continuously moist for at least 10 days.

7.21.1.4 The procedure for mixing the floor hardener topping shall be as per manufacturer's instructions.

7.21.1.5 Surface shall be prevented from any damages due to subsequent building operations by covering with 75 mm thick layer of sand.

7.22 PVC Sheet/Tile Flooring

7.22.1 Materials

7.22.1.1 PVC floor covering shall be of either unbacked homogeneous flexible type in the form of sheets/tiles conforming to IS:3462 or homogeneous PVC asbestos tiles conforming to IS:3461.

7.22.1.2 The surface of the sheets/tiles shall be free from any physical defects such as pores, blisters, cracks etc. which affects the appearance and serviceability. Tiles/ sheets shall meet with the tolerance limits in dimensions specified in the IS. Contractor shall submit the test certificates, if so desired by the EMPLOYER.

7.22.1.3 Each tile/sheet shall be legibly and indelibly marked with the name of the manufacturer or his trade mark, IS certificate mark, and batch number.

7.22.1.4 The adhesive to be used for laying the PVC flooring shall be rubber based and of the make as recommended and approved by the manufacturer of PVC sheets/tiles.

7.22.1.5 The type, size, colour, plain or mottled and the pattern shall be as specified in the respective items of work prepared by the Contractor.

7.22.2 Workmanship

7.22.2.1 PVC Floor covering shall be provided over an under bed of cement concrete floor finish over the base concrete or structural slab. It is essential that the sub-floor and the under bed are perfectly dry before laying the PVC flooring. This shall be ensured by methods of testing as stipulated in Appendix-A of IS:5318.

7.22.2.2 The surface of the under bed shall have trowelled finish without any irregularities, which creates poor adhesion. Surface shall be free of oil or grease and thoroughly cleaned of all dust, dirt and wiped with a dry cloth.

7.22.2.3 PVC sheets/tiles shall be brought to the temperature of the area in which they are to be laid by stacking in a suitable manner within or near the laying area for a period of about 24 hours. Where air-conditioning is installed, the flooring shall not be laid on the under bed until the A/C units have been in operation for at least 7 days. During

this period, the temperature range shall be between 20deg.C and 30deg.C and this shall be maintained during the laying operations and also for 48 hours thereafter.

7.22.2.4 Layout of the PVC flooring shall be marked with guidelines on the under bed and PVC tiles/sheets shall be first laid for trial, without using the adhesive, according to the layout.

7.22.2.5 The adhesive shall be applied by using a notched trowel to the surface of the under bed and to the backside of PVC sheets/tiles. When the adhesive has set sufficiently for laying, it will be tacky to the touch, which generally takes about 30 minutes. The time period need be carefully monitored since a longer interval will affect the adhesive properties. Adhesive shall be uniformly spread over only as much surface area at one time which can be covered with PVC flooring within the stipulated time.

7.22.2.6 PVC sheet shall be carefully taken and placed in position from one end onwards slowly so that the air will be completely squeezed out between the sheet and the background surface and no air pockets are formed. It shall then be pressed with a suitable roller to develop proper contact. The next sheet shall be laid edge to edge with the sheet already laid, so that there is minimum gap between joints. The alignment shall be checked after each row of sheet is completed and trimmed if considered necessary.

7.22.2.7 Tiles shall be laid in the same manner as sheets and preferably, commencing from the centre of the area. Tiles should be lowered in position and pressed firmly on to the adhesive with minimum gap between the joints. Tiles shall not be slided on the surface. Tiles shall be rolled with a light wooden roller of about 5kg to ensure full contact with the underlay. Work should be constantly checked to ensure that all four edges of adjacent tiles meet accurately.

7.22.2.8 Any excess adhesive which may squeeze up between sheets/tiles shall be wiped off immediately with a wet cloth. Suitable solvents shall be used to remove hardened adhesive.

7.22.2.9 A minimum period of 24 hours shall be given after laying for the development of proper bond of the adhesive. When the flooring is thus completed, it shall be cleaned with a wet cloth soaked in warm soap solution.

7.22.2.10 Metallic edge strips shall be used to protect the edges of PVC sheets/tiles which are exposed as in doorways/ stair treads.

7.22.2.11 Hot sealing of joints between adjacent PVC sheet flooring to prevent creeping of water through the joints shall be carried out, using special equipment as per manufacturer's instructions.

7.23 Acid Resisting Brick/Tiling Work

7.23.1 Materials

7.23.1.1 The ceramic unglazed vitreous acid resisting tiles shall conform to the requirements of IS:4457. Acid resistant bricks shall conform to the requirements of IS:4860.

7.23.1.2 The finished tile/brick when fractured shall appear fine grained in texture, dense and homogeneous. Tile/brick shall be sound, true to shape, flat, free from flaws and any manufacturing defects affecting their utility. Tolerance in dimensions shall be within the limits specified in the respective IS.

7.23.1.3 The tiles/bricks shall be bedded and jointed using chemical resistant mortar of the resin type conforming to IS:4832 (Part II). Method of usage shall generally be as per the requirements of IS:4443.

7.23.2 Workmanship

7.23.2.1 The resin shall have viscosity for readily mixing with the filler by manual methods. The filler shall have graded particles which permit joint thickness of 1.5 mm.

7.23.2.2 The base concrete surface shall be free from dirt and thoroughly dried. The surface shall be applied with a coat of bitumen primer conforming to IS:3384. The primed surface shall then be applied with a uniform coat of bitumen conforming to IS:1580. Tiles or bricks shall be laid directly without the application of bitumen, if epoxy or polyester resin is used for the mortar.

7.23.2.3 Just adequate quantity of mortar which can be applied within the pot life as specified by the manufacturer shall be prepared at one time for bedding and jointing. Rigid PVC/Stainless steel/chromium plated tools shall be used for mixing and laying.

7.23.2.4 For laying the floor 6 to 8 mm thick mortar shall be spread on the back of the tile/brick. Two adjacent sides of the tile/brick shall be smeared with 4 to 6 mm thick mortar. Tile/brick shall be pressed into the bed and pushed against the floor and with the adjacent tile/ brick, until the joint in each case is 2 to 3 mm thick. Excess mortar shall then be trimmed off and allowed to harden fully. Similar procedure shall be adopted for the work on walls by pressing the tile/brick against the prepared wall surfaces and only one course shall be laid at a time until the initial setting period.

7.23.2.5 The mortar joints shall be cured for a minimum period of 72 hours with 20 to 25% hydrochloric acid or 30 to 40% sulphuric acid. After acid curing, the joints shall be washed with water and allowed to thoroughly dry. The joints shall then be filled with mortar to make them smooth and plane. Acid curing is not required to be carried out if epoxy or polyester resin is used for the mortar.

7.23.2.6 Resin mortars are normally self curing. The area tiled shall not be put to use before 48 hours in case epoxy, polyester and furane type of resin is used for the mortar. If phenolic or cashewnut shell liquid resin is used for the mortar, the area tiled shall not be put to use for 7 to 28 days respectively, without heat treatment. This period shall be 2 to 6 days respectively, if heat treatment is given with infrared lamp.

7.24 Epoxy Lining Work

7.24.1 Materials

7.24.1.1 The epoxy resin and hardener formulation for laying of jointless lining work in floors and walls of concrete tanks/trenches etc shall be as per the requirements of IS:9197.

7.24.1.2 The epoxy composition shall have the chemical resistance to withstand the following conditions of exposure:

a) Hydrochloric acid upto 30% concentration
b) Sodium hydroxide upto 50% concentration
c) Liquid temperature upto 60deg.C
d) Ultraviolet radiation
e) Alternate wetting and drying

7.24.1.3 Sand shall conform to grading zone III or IV of IS:383.

7.24.1.4 The hardener shall be of the liquid type such as Aliphatic Amine or an Aliphatic/Aromatic Amine Adduct for the epoxy resin. The hardener shall react with epoxy resin at normal ambient temperature.

7.24.1.5 Contractor shall furnish test certificates for satisfying the requirements of the epoxy formulation if so directed by the EMPLOYER.

7.24.2 Workmanship

7.24.2.1 The minimum thickness of epoxy lining shall be 4 mm. It is essential that the concrete elements are adequately designed to ensure that water is excluded to permeate to the surface, over which the epoxy lining is proposed.

7.24.2.2 The epoxy lining shall be of the trowel type to facilitate execution of the required thickness for satisfactory performance.

7.24.2.3 The concrete surfaces over which epoxy lining is to be provided shall be thoroughly cleaned of oil or grease by suitable solvents, wire brushed to remove any dirt/dust and laitance. The surfaces shall then be washed with dilute hydrochloric acid and rinsed thoroughly with plenty of water or dilute ammonia solution. The surfaces shall then be allowed to dry. It is essential to ensure that the surfaces are perfectly dry before the commencement of epoxy application.

7.24.2.4 Just adequate quantity of epoxy resin which can be applied within the pot life as specified by the manufacturer shall be prepared at one time for laying and jointing.

7.24.2.5 Rigid PVC/stainless steel/chromium plated tools shall be used for laying. Trowelling shall be carried out to obtain uniformly the specified thickness of lining.

7.24.2.6 Lining shall be allowed to set without disturbance for a minimum period of 24 hours. The facility shall be put to use only after a minimum period of 7 days of laying of the lining.

7.25 Water-Proofing

7.25.1 General

7.25.1.1 The work shall include waterproofing for the building roofs, terraces, toilets, floor slabs, walls, planters, chajjas, sills and any other areas and at any other locations and situations as directed by the Employers Representative.

7.25.1.2 The waterproofing treatment shall be carried out on top of lime concrete (brick bat coba) laid to slope on roof surfaces. The brick bat coba shall be covered as specified below.

7.25.1.3 The work shall be carried out by an experienced specialist Sub-Contractor who shall be appointed only after prior approval of the EMPLOYER.

7.25.2 Modified Bituminous Membrane

7.25.2.1 Modified Bituminous Membrane shall be "SUPER THERMOLAY" 4 mm thick weighing 4 Kg/sqm, manufactured using APP Polymer modified bitumen with a central core of non-woven polyester reinforcement (200 gms/sqm) and with top and bottom layers of thermofusible film (top layer could also be sand finished) made by STP Limited in collaboration with Bitumat Company Limited. "PLYFLEX" of Bitumat Company Limited, Saudi Arabia supplied by STP Limited shall also be acceptable or other equivalent specification.

7.25.3 Waterproofing of Roofs with Lime Concrete

7.25.3.1 Materials

a) Broken brick coarse aggregates prepared from well/over burnt bricks shall be well graded having a maximum size of 25mm and shall generally conform to IS:3068.
b) Lime shall be class C lime (fat lime) or factory made hydrated lime conforming to IS:712.

7.25.3.2 Workmanship

7.25.3.2.1 Lime concrete shall be prepared by thoroughly mixing the brick aggregates inclusive of brick dust obtained during breaking with the slaked lime in the proportions of 2 1/2 (two and a half) parts of brick aggregates to 1 part of slaked lime by volume. Water shall be added just adequate to obtain the desired workability for laying. Washing soap and alum shall be dissolved in the water to be used. The quantity of these materials required per cum of lime concrete shall be 12kg of washing soap and 4kg of alum. Brick aggregates shall be soaked thoroughly in water for a period of not less than six hours before use in the

concrete mix. Lime concrete shall be used in the works within 24 hours after mixing.

7.25.3.2.2 The roof surface over which the water-proof treatment is to be carried out shall be cleaned of all foreign matter by wire brushing, dusting and made thoroughly dry. Preparation of surfaces shall be as stipulated in IS:3067.

7.25.3.2.3 The slope of the finished waterproofing treatment shall be not less than 1 in 60 for efficient drainage. This shall be achieved either wholly in the lime concrete layer.

7.25.3.2.4 The average thickness of lime concrete, slope and the finish on top of machine made burnt clay flat terracing tiles conforming to IS:2690 (part I) shall be as specified in the items of work to be prepared by the Contractor. Cement concrete flooring tiles in lieu of clay terracing tiles shall be provided if so specified in the items of work prepared by the Contractor, duly considering the traffic the terrace will be subjected to.

7.25.3.2.5 The minimum compacted thickness of lime concrete layer shall be 75mm and average thickness shall not be less than 100mm. In case, the thickness is more than 100mm, it shall be laid in layers not exceeding 100mm to 125mm.

7.25.3.2.6 Laying of lime concrete shall be commenced from a corner of the roof and proceeded diagonally towards centre and other sides duly considering the slopes specified for effectively draining the rain-water towards the downtake points.

7.25.3.2.6 Lime concrete fillet for a minimum height of 150mm shall be provided all along the junction of the roof surface with the brick masonry wall/parapet/column projections. These shall then be finished on top with provision of clay terracing tiles/cement concrete tiles.

7.25.3.2.7 After the lime concrete is laid it shall be initially rammed with a rammer weighing not more than 2 Kg and the finish brought to the required evenness and slope. Alternatively, bamboo strips may be used for the initial ramming. Further consolidation shall be done using wooden THAPIES with rounded edges. The beating will normally have to be carried on for at least seven days until the THAPI makes no impression on the surface and rebounds readily from it when struck. Special care shall be taken to properly compact the lime concrete at its junction with parapet walls or column projections.

7.25.3.2.8 During compaction by hand-beating, the surface shall be sprinkled liberally with lime water (1 part of lime putty and 3 to 4 parts of water) and a small proportion of sugar solution for obtaining improved water-proofing quality of the lime concrete. On completion of beating, the mortar that comes on the top shall be smoothened with a trowel or float, if necessary, with the addition of sugar solution and lime putty. The sugar solution may be prepared in any one of the following ways as directed by the EMPLOYER.

a) By mixing about 3 Kg of Jaggery and 1.5 Kg of BAEL fruit to 100 litres of water.

b) By mixing about 600 gm of KADUKAI (the dry nuts shall be broken to small pieces and allowed to soak in water), 200 gm of jaggery and 40 litres of water for 10 sq.m of work. This solution shall be brewed for about 12 to 24 hours and the resulting liquor decanted and used for the work.

7.25.3.2.9 The lime concrete after compaction shall be cured for a minimum period of seven days or until it hardens by covering with a thin layer of straw or hessian which shall be kept wet continuously.

7.25.3.2.10 Machine made flat terracing tiles shall be of the size and thickness as specified. Tiles shall be soaked in water for at least one hour before laying. Bedding for the tiles shall be 12mm thick in cement mortar 1:3. Tiles shall be laid, open jointed with 4 to 6 mm wide joints, flat on the mortar and lightly pressed and set to plane surface true to slope, using a trowel and wooden straight edge. They shall be laid with their longitudinal lines of joints truly parallel and generally at right angles to the direction of run-off gradient. Transverse joints in alternate rows shall come directly in line with each other. Transverse joints in adjacent courses shall break joints by at least 50 mm. The joints shall be completely filled and flush pointed with cement mortar 1:2 mixed with water proofing compound as per manufacturer's instructions. Curing shall be carried out for a minimum period of seven days.

7.25.3.2.11 Finishing on top with cement concrete tiles or in-situ cement concrete floor topping shall be carried out in similar fashion as described for clay tiles in above paragraph. Tiles to be used shall be supplied after the first machine grinding of the surface.

7.25.4 Waterproofing of Roofs/Terraces etc.

(a) Water proofing of Horizontal Surfaces

7.25.4.1 The waterproofing shall be applied as follows:

7.25.4.2 A coat of Blown Bitumen 85/25 shall be applied at the rate of 1.45 kg/sq.km

7.25.4.3 A roll of Modified Bituminous Membrane shall be unrolled over the primed surface and completely bonded to the substrate by pressing down evenly for the full width of the roll using a wooden roller. Torching shall be done, where recommended by the manufacturer and where directed by the EMPLOYER, as the unrolling progresses.

7.25.4.4 The side overlaps shall be minimum 100 mm whereas the end overlaps shall be minimum 150 mm; both shall be bonded and sealed by flame torching.

7.25.4.5 Care shall be taken that the membrane is lapped with the treatment along the vertical surface and roof gutter treatment for at least 500 mm.

7.25.4.6 The membrane shall be properly overlapped/terminated at all openings, rainwater down takes etc. to ensure that such junctions do not become sources of leakage.

7.25.4.7 Top of membrane finally shall be painted with antiglouse reflective paint.

(b) Waterproofing of Vertical Surfaces at Roof Level and Gutters

7.25.4.8 The Water proofing shall be applied as described in (a) above.

7.25.4.9 Modified Bituminous membrane shall be unrolled and bonded to the substrate after applying a coat of bitumen and by pressing down evenly for the full width of the roll. Light torching shall be done to ensure complete bonding.

7.25.4.10 The membrane shall be overlapped with treatment for the horizontal surface by at least 500 mm.

7.25.4.11 The membrane shall be taken upto a pre-cut chase anchored and sealed.

7.25.5 Khurras and Rainwater Down Pipes

7.25.5.1 Down pipes shall be isolated from RCC work with 6 mm polyethylene foam fixed with adhesive (Araldite) and sealed with silicone sealant prior to laying membrane. A water proofing flashing composed of one layer of Hessian based self finished felt Type 3 Grade 1 and two layers of aluminium foil of 0.075 mm thickness shall be provided. This flashing shall be carried into the down take pipes for at least 150 mm and sealed with hot bitumen. The Contractor shall closely coordinate the work with the agency providing and fixing the rainwater down take pipes.

7.25.6 Testing

7.25.6.1 The treated area (flat and horizontal only) shall be tested by allowed water to stand on the treated areas to a depth of 150 mm for a minimum period of 72 hours.

7.25.6.2 The treated area (flat and horizontal) shall have continuous slope towards the rainwater outlets and no water shall pond any where on the surface.

7.26 Cement Plastering Work

7.26.1 Materials

7.26.1.1 The proportions of the cement mortar for plastering shall be 1:3 (one part of cement to three parts of sand). Cement and sand shall be mixed thoroughly in dry condition and then just enough water added to obtain a workable consistency. The quality of water and cement shall be as per relevant IS standards. The quality and grading of sand for plastering shall conform to IS:1542. The mixing shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the EMPLOYER. If so desired by the EMPLOYER sand shall be screened and washed to meet the Specifications. The mortar thus mixed shall be used as soon as possible preferably within 30 minutes from the time water is added to cement. In case the mortar has stiffened due to evaporation of water this may be re- tempered by adding water as required to restore consistency but this will be permitted only upto 30 minutes from the time of initial mixing of water to cement. Any mortar

which is partially set shall be rejected and removed forthwith from the site. Droppings of plaster shall not be re-used under any circumstances.

7.26.2 Workmanship

7.26.2.1 Preparation of surfaces and application of plaster finishes shall generally conform to the requirements specified in IS:1661 and IS:2402.

7.26.2.2 Plastering operations shall not be commenced until installation of all fittings and fixtures such as door/window panels, pipes, conduits etc. are completed.

7.26.2.3 All joints in masonry shall be raked as the work proceeds to a depth of 10mm/20mm for brick/stone masonry respectively with a tool made for the purpose when the mortar is still green. The masonry surface to be rendered shall be washed with clean water to remove all dirt, loose materials, etc., Concrete surfaces to be rendered shall be roughened suitably by hacking or bush hammering for proper adhesion of plaster and the surface shall be evenly wetted to provide the correct suction. The masonry surfaces should not be too wet but only damp at the time of plastering. The dampness shall be uniform to get uniform bond between the plaster and the masonry surface.

7.26.2.4 Interior plain faced plaster - This plaster shall be laid in a single coat of 13mm thickness. The mortar shall be dashed against the prepared surface with a trowel. The dashing of the coat shall be done using a strong whipping motion at right angles to the face of the wall or it may be applied with a plaster machine. The coat shall be trowelled hard and tight forcing it to surface depressions to obtain a permanent bond and finished to smooth surface. Interior plaster shall be carried out on jambs, lintel and sill faces, etc. as shown in the drawing and as directed by the EMPLOYER.

7.26.2.5 Plain Faced Ceiling plaster - This plaster shall be applied in a single coat of 6mm thickness. Application of mortar shall be as stipulated in above paragraph.

7.26.2.6 Exterior plain faced plaster - This plaster shall be applied in 2 coats. The first coat or the rendering coat shall be approximately 14mm thick. The rendering coat shall be applied as stipulated above except finishing it to a true and even surface and then lightly roughened by cross scratch lines to provide bond for the finishing coat. The rendering coat shall be cured for at least two days and then allowed to dry. The second coat or finishing coat shall be 6 mm thick. Before application of the second coat, the rendering coat shall be evenly damped. The second coat shall be applied from top to bottom in one operation without joints and shall be finished leaving an even and uniform surface. The mortar proportions for the coats shall be as specified in the respective item of work. The finished plastering work shall be cured for at least 7 days.

7.26.2.7 Interior plain faced plaster 20mm thick if specified for uneven faces of brick walls or for random/coursed rubble masonry walls shall be executed in 2 coats similar to the procedure stipulated in above paragraph.

7.26.2.8 Exterior Sand Faced Plaster- This plaster shall be applied in 2 coats. The first coat shall be approximately 14mm thick and the second coat shall be 6mm thick. These coats shall be applied as stipulated above. However, only approved quality white sand shall be used for the second coat and for the finishing work. Sand for the finishing work shall be coarse and of even size and shall be dashed against the surface and sponged. The mortar proportions for the first and second coats shall be as specified in the respective items of work.

7.26.2.9 Wherever more than 20mm thick plaster has been specified, which is intended for purposes of providing beading, bands, etc. this work shall be carried out in two or three coats as directed by the EMPLOYER duly satisfying the requirements of curing each coat (rendering/floating) for a minimum period of 2 days and curing the finished work for at least 7 days.

7.26.2.10 In the case of pebble faced finish plaster, pebbles of approved size and quality shall be dashed against the final coat while it is still green to obtain as far as possible a uniform pattern all as directed by the EMPLOYER.

7.26.2.11 Where specified in the Drawings to be prepared by the Contractor prepared by the Contractor, rectangular grooves of the dimensions indicated shall be provided in external plaster by means of timber battens when the plaster is still in green condition. Battens shall be carefully removed after the initial set of plaster and the broken edges and corners made good. All grooves shall be uniform in width and depth and shall be true to the lines and levels as per the Drawings to be prepared by the Contractor prepared by the Contractor.

7.26.2.12 Curing of plaster shall be started as soon as the applied plaster has hardened sufficiently so as not to be damaged when watered. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least 7 days.

7.26.2.13 For waterproofing plaster, the Contractor shall provide the water-proofing admixture as specified in manufacturers instruction while preparing the cement mortar.

7.26.2.14 For external plaster, the plastering operations shall be commenced from the top floor and carried downwards. For internal plaster, the plastering operations for the walls shall commence at the top and carried downwards. Plastering shall be carried out to the full length of the wall or to natural breaking points like doors/windows etc. Ceiling plaster shall be completed first before commencing wall plastering.

7.26.2.15 Double scaffolding to be used shall be as specified in clause 7.2.2.

7.26.2.16 The finished plaster surface shall not show any deviation more than 4mm when checked with a straight edge of 2m length placed against the surface.

7.26.2.17 To overcome the possibility of development of cracks in the plastering work following measures shall be adopted.

a) Plastering work shall be deferred as much as possible so that fairly complete drying shrinkage in concrete and masonry works takes place.
b) Steel wire fabric shall be provided at the junction of brick masonry and concrete to overcome reasonably the differential drying shrinkage/thermal movement.
c) Ceiling plaster shall be done, with a trowel cut at its junction with wall plaster. Similarly trowel cut shall be adopted between adjacent surfaces where discontinuity of the background exists.

7.27 Cement Pointing

7.27.1 Materials

7.27.1.1 The cement mortar for pointing shall be in the proportion of 1:3 (one part of cement to three parts of fine sand). Sand shall conform to IS: 1542 and shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by EMPLOYER and if so directed it shall be washed/screened to meet specification requirements.

7.27.2 Workmanship

7.27.2.1 Where pointing of joints in masonry work is specified, the joints shall be raked at least 15mm/20mm deep in brick/stone masonry respectively as the work proceeds when the mortar is still green.

7.27.2.2 Any dust/dirt in the raked joints shall be brushed out clean and the joints shall be washed with water. The joints shall be damp at the time of pointing. Mortar shall be filled into joints and well pressed with special steel trowels. The joints shall not be disturbed after it has once begun to set. The joints of the pointed work shall be neat. The lines shall be regular and uniform in breadth and the joints shall be raised, flat, sunk or 'V' as may be specified in the respective items of work. No false joints shall be allowed.

7.27.2.3 The work shall be kept moist for at least 7 days after the pointing is completed. Whenever coloured pointing has to be done, the colouring pigment of the colour required shall be added to cement in such proportions as recommended by the manufacturer and as approved by the EMPLOYER.

7.28 Water-Proofing Admixtures

7.28.1 Water-proofing admixture shall conform to the requirements of IS:2645 and shall be of approved manufacture. The admixture shall not contain calcium chloride. The quantity of the admixture to be used for the works and method of mixing etc. shall be as per manufacturer's instructions and as directed by the EMPLOYER.

7.29 Painting of Concrete, Masonry & Plastered Surfaces

7.29.1 Materials

7.29.1.1 Oil bound distemper shall conform to IS:428. The primer shall be alkali resistant primer of the same manufacture as that of the distemper.

7.29.1.2 Cement paint shall conform to IS:5410. The primer shall be a thinned coat of cement paint.

7.29.1.3 Lead free acid, alkali and chlorine resisting paint shall conform to IS:9862.

7.29.1.4 Colour wash shall be made by addition of a suitable quantity of mineral pigment, not affected by lime, to the prepared white wash to obtain the shade/tint as approved by the EMPLOYER.

7.29.1.5 All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the EMPLOYER for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

7.29.2 Workmanship

2.29.2.1 Contractor shall obtain the approval of the EMPLOYER regarding the readiness of the surfaces to receive the specified finish, before commencing the work on painting.

2.29.2.2 Painting of new surfaces shall be deferred as much as possible to allow for thorough drying of the sub- strata.

2.29.2.3 The surfaces to be treated shall be prepared by thoroughly brushing them free from dirt, mortar droppings and any loose foreign materials. Surfaces shall be free from oil, grease and efflorescence. Efflorescence shall be removed only by dry brushing of the growth. Cracks shall be filled with Gypsum. Workmanship of painting shall generally conform to IS:2395.

2.29.2.4 Surfaces of doors, windows etc. shall be protected suitably to prevent paint finishes from splashing on them.

7.29.3 White Wash

7.29.3.1 The prepared surfaces shall be wetted and the finish applied by brushing. The operation for each coat shall consist of a stroke of the brush first given horizontally from the right and the other from the left and similarly, the subsequent stroke from bottom upwards and the other from top downwards, before the first coat dries. Each coat shall be allowed to dry before the next coat is applied. Minimum of 2 coats shall be applied unless otherwise specified. The dry surface shall present a uniform finish without any brush marks.

7.29.4 Colour Wash

7.29.4.1 Colour wash shall be applied in the same way as for white wash. A minimum of 2 coats shall be applied unless otherwise specified. The surface shall present a smooth

and uniform finish without any streaks. The finished dry surface shall not show any signs of peeling/powdery and come off readily on the hand when rubbed.

7.29.5 Cement Paint

7.29.5.1 The prepared surfaces shall be wetted to control surface suction and to provide moisture to aid in proper curing of the paint. Cement paint shall be applied with a brush with stiff bristles. The primer coat shall be a thinned coat of cement paint. The quantity of thinner shall be as per manufacturer's instructions. The coats shall be vigorously scrubbed to work the paint into any voids for providing a continuous paint film free from pinholes for effective water proofing in addition to decoration. Cement paint shall be brushed in uniform thickness and the covering capacity for two coats on plastered surfaces shall be 3 to 4 kg/sq.m. A minimum of 2 coats of the same colour shall be applied. At least 24 hours shall be left after the first coat to become sufficiently hard before the second coat is applied. The painted surfaces shall be thoroughly cured by sprinkling with water using a fog spray at least 2 to 3 times a day. Curing shall commence after about 12 hours when the paint hardens. Curing shall be continued for at least 2 days after the application of final coat. The operations for brushing each coat shall be as detailed above.

7.29.6 Oil bound Distemper

7.29.6.1 The prepared surfaces shall be dry and provided with one coat of alkali resistant primer by brushing. The surface shall be finished uniformly without leaving any brush marks and allowed to dry for at least 48 hours. A minimum of two coats of oil bound distemper shall be applied, unless otherwise specified. The first coat shall be of a lighter tint. At least 24 hours shall be left after the first coat to become completely dry before the application of the second coat. Broad, stiff, double bristled distemper brushes shall be used for the work. The operations for brushing each coat shall be as detailed above.

7.29.7 Acid, Alkali Resisting Paint

7.29.7.1 A minimum of 2 coats of acid/alkali resisting paint shall be applied over the prepared dry surfaces by brushing. Primer coat shall be as per manufacturer's instructions.

7.29.8 Plastic Emulsion Paint

7.29.8.1 The prepared surface shall be dry and provided with one coat of primer which shall be a thinned coat of emulsion paint. The quantity of thinner shall be as per manufacturer's instructions. The paint shall be laid on evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard for the first time over and then brushing alternately in opposite directions two or three times and then finally brushing lightly in a direction at right angles. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off constitutes one coat. The next coat shall be applied only after the first coat has dried and sufficiently become hard which normally takes about 2 to 3 hours. A minimum of 2 finishing coats of the same colour shall be applied unless otherwise specified.

Paint may also be applied using rollers. The surface on finishing shall present a flat velvety smooth finish and uniform in shade without any patches.

7.29.9 Acrylic Emulsion Paint

7.29.9.1 Acrylic emulsion paint shall be applied in the same way as for plastic emulsion paint. A minimum of 2 finishing coats over one coat of primer shall be provided unless otherwise specified.

7.30 Painting & Polishing of Wood Work

7.30.1 Materials

a) Wood primer shall conform to IS:3536.
b) Filler shall conform to IS:110.
c) Varnish shall conform to IS:337.
d) French polish shall conform to IS:348.
e) Synthetic enamel paint shall conform to IS:2932.

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the EMPLOYER for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

7.30.2 Workmanship

7.30.2.1 The type of finish to be provided for woodwork of either painting or polishing, the number of coats, etc. shall be as specified in the respective items of work to be prepared by the Contractor.

7.30.2.2 Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

7.30.2.3 Painting shall be either by brushing or spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirements of IS:2338 (Part I).

7.30.2.4 All the wood surfaces to be painted shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it across the grains and dusted off. Wood primer coat shall then be applied uniformly by brushing. The number of primer coats shall be as specified in the item of work to be prepared by the Contractor. Any slight irregularities of the surface shall then be made- up by applying an optimum coat of filler conforming to IS:110 and rubbed down with an abrasive paper for obtaining a smooth surface for the undercoat of synthetic enamel paint conforming to IS:2932. Paint shall be applied by brushing evenly and smoothly by means of crossing and laying off in the direction of the grain of wood. After drying, the coat shall be carefully rubbed down using very fine grade of sand paper and wiped clean before the next coat is applied. At least 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the EMPLOYER. The number of coats of paint to be applied shall be as specified in the item of work to be prepared by the Contractor.

7.30.2.5 All the wood surfaces to be provided with clear finishes shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it in the direction of the grains and dusted off. Any slight irregularities of the surface shall be made up by applying an optimum coat of transparent liquid filler and rubbed down with an abrasive paper for obtaining a smooth surface. All dust and dirt shall be thoroughly removed. Over this prepared surface, varnish conforming to IS:337 shall be applied by brushing. Varnish should not be retouched once it has begun to set. Staining if required shall be provided as directed by the EMPLOYER. When two coats of varnish is specified, the first coat should be a hard-drying undercoat or flatting varnish which shall be allowed to dry hard before applying the finishing coat. The number of coats to be applied shall be as specified. For works where clear finish of French polish is specified the prepared surfaces of wood shall be applied with the polish using a pad of woolen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles to give an even finish over the entire area. The surface shall be allowed to dry before applying the next coat. Finishing shall be carried out using a fresh clean cloth over the pad, slight dampening with methylated spirit and rubbing lightly and quickly in circular motions. The finished surface shall have a uniform texture and high gloss. The number of coats to be applied shall be as specified.

7.31 Painting of Steel Work

7.31.1 Materials

a) Red-oxide – zinc chrome primer shall conform to IS:2074.
b) Synthetic enamel paint shall conform to IS : 2932.
c) Aluminium paint shall conform to IS:2339.

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the EMPLOYER for the brand of manufacture and the colour/shade. All the materials shall be brought to the site in sealed containers.

7.31.2 Workmanship

7.31.2.1 Painting work shall be carried out only on thoroughly dry surfaces. Painting shall be applied either by brushing or by spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirement of IS:1477 (Part 2).

7.31.2.2 The type of paint, number of coats etc. shall be as specified in the respective items of work.

7.31.2.3 Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

7.31.2.4 All the surfaces shall be thoroughly cleaned of oil, grease, dirt, rust and scale. The methods to be adopted using solvents, wire brushing, power tool cleaning etc., shall be as per IS:1477 (Part – I) and as indicated in the item of work.

7.31.2.5 It is essential to ensure that immediately after preparation of the surfaces, the first coat of red oxide-zinc chrome primer shall be applied by brushing and working it well to ensure a continuous film without holidays. After the first coat becomes hard dry, a second coat of primer shall be applied by brushing to obtain a film free from `holidays'.

7.31.2.6 After the second coat of primer is hard dry, the entire surface shall be wet rubbed cutting down to a smooth uniform surface. When the surface becomes dry, the undercoat of synthetic enamel paint of optimum thickness shall be applied by brushing with minimum of brush marks. The coat shall be allowed to hard-dry. The under coat shall then be wet rubbed cutting down to a smooth finish, taking adequate care to ensure that at no place the undercoat is completely removed. The surface shall then be allowed to dry.

7.31.2.7 The first finishing coat of paint shall be applied by brushing and allowed to hard-dry. The gloss from the entire surface shall then be gently removed and the surface dusted off. The second finishing coat shall then be applied by brushing.

7.31.2.8 At least 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the EMPLOYER.

7.32 Flashing

7.32.1 Materials

7.32.1.1 Anodised Aluminium sheets shall be 1.00mm thick with anodic film thickness of 0.025 mm.

7.32.1.2 Galvanised mild steel sheets shall be 1.00mm thick with zinc coating of 800 gms/sq.m.

7.32.1.3 Bitumen felt shall be either Hessian base self finished bitumen felt Type-3 Grade I conforming to IS:1322 or glass fibre base self finished felt Type-2 Grade 1 conforming to IS:7193.

7.32.2 Workmanship

7.32.2.1 The type of the flashing and method of fixing shall be as specified.

7.32.2.2 Flashing shall be of the correct shape and size as indicated in the construction Drawings to be prepared by the Contractor and they shall be properly fixed to ensure their effectiveness.

7.32.2.3 Flashing shall be of long lengths so as to provide minimum number of joints. The minimum overlap at joints shall be 100mm.

7.32.2.4 Fixing of the flashing shall be either by bolting with bitumen washers or by tucking into the groove 75 mm wide x 65 mm deep in masonry/concrete along with cement mortar 1:4 filletting as indicated in the Drawings to be prepared by the Contractor. Curing of the mortar shall be carried out for a minimum period of 4 days.

7.32.2.5 Bitumen felt flashing of the type as specified shall be provided with 2 coats of bituminous paint at the rate of 0.10 litre/sq.m after the installation.

7.33 Thermal Insulation For Ceiling

Thermal insulation shall be "Thermocole" TF type or similar approved or Resin bonded fibre glass boards.

7.33.1 Fixing

7.33.2 "Thermocole" Boards

7.33.2.1 Soffit of R.C.Slab shall be thoroughly cleaned with wire brush and 85/25 industrial grade hot bitumen conforming to IS:702 shall be applied uniformly over the surface at the rate of 1.5 Kg/m^2.

7.33.2.2 Thermocole boards (T.F. variety) of 50mm thickness shall be stuck by means of the same grade of hot bitumen.

7.33.2.3 The boards shall be further secured with screws, washers and plugs.

7.33.2.4 The joints of the boards shall be sealed with bitumen.

7.33.3 Fibre Glass Boards

7.33.3.1 Timber pegs 50mm x 50mm x 50mm shall be fixed to the slab at 600mm centres with 6mm x 65mm long wood screws. 20 gauge G.I. lacing wire shall be tied to the pegs.

7.33.3.2 `Crown' 200 fibre glass boards 50mm thick shall be stuck to the pegs with CPRX compound or any other suitable adhesive and be held in position by the 20 gauge G.I. lacing wires.

7.33.3.3 The insulation boards shall be covered with 20mm – 24 gauge hexagonal G.I. chicken wire mesh, nailed to the timber pegs and 30 gauge aluminium sheets shall be fixed over the chicken wire mesh with 50mm overlap and secured to the timer pegs by screws.

7.33.3.4 If the insulation is specified to rest on top of the false ceiling, it shall be properly installed and anchored to the framework. In case additional battens are required for proper installation, Contractor shall include its cost in the rate for insulation.

7.34 Plaster of Paris Board for False Ceiling

7.34.1 Materials

7.34.1.1 Plaster of Paris Boards

a) The plaster of paris boards to be used in the false ceiling shall be of an approved manufacture or manufactured at site by methods and materials approved by EMPLOYER.

b) The plaster of paris shall be of the calcium-sulphate hemi-hydrate variety and shall contain not less than 35 percent sulphur trioxide and other requirements as per IS:2547 (Part I) However, its fineness shall be such that the residue, after drying, and sieving on I.S. sieve designation 3.35mm for 5 minutes shall not be more than 1 percent by weight. Initial setting time shall not be less than 13 minutes. The average compressive strength of plaster determined by testing 5 cm cubes 24 hours after removal from moulds and drying in an oven at 40 Deg. C till the weight of the cubes is constant, shall not be less than 84 Kg per sq.cm.

c) The plaster of paris boards reinforced with hessian cloth or coir shall be prepared in suitable sizes as shown on the drawings or as directed by EMPLOYER. Wooden forms of height equal to the thickness of boards shall be placed on truly level and smooth surface such as a glass sheet. The edges of the boards shall be truly square. The glass sheet or surface on which form is kept and the form sides shall be given a thin coat of non-staining oil to facilitate the easy removal of the board. Plaster of paris shall be evenly spread into the form upto about half the depth and hessian cloth or coir shall be pressed over the plaster of paris layer. The weight of hessian cloth or coir in the board shall be 250 gm per sq.m. The ends of the hessian/coir reinforcement shall be turned over at all edges to form a double layer for a width of 50mm. The hessian cloth shall be of an open web texture so as to allow the plaster below and above to intermix with each other and form an integral board. The form shall then be filled with plaster of paris which shall be uniform pressed and then wire cut to an even and smooth surface. The board shall then be allowed to set initially for an hour or so and then removed from the form and allowed to dry and harden for about a week. The board after drying and hardening shall give a ringing sound when struck. The boards shall be true and exact to shape and size and the exposed face shall be truly plane and smooth.

d) The size of boards shall generally be 600mm x 600 mm x 12 mm thick. Boards shall be kept dry in transit and stored flat in a clean dry place and shall not be exposed to moisture. The boards shall always be carried on edges.

7.34.2 Timber Frame Work

7.34.2.1 Timber for frame work of false ceiling grid and hangers shall be of good quality and well seasoned. It shall have uniform colour, reasonably straight and close grains and shall be free from knots, cracks and sapwood. It shall be treated with approved anti-termite preservative as directed by the EMPLOYER. Extreme care shall be taken so that the preservative treatment does not stain the ceiling boards. In case metal hangers are used, these shall be M.S. flats or bars, having two coats of

red oxide zinc chromate paint primer, as shown on drawings or as approved by EMPLOYER.

7.34.3 Metal Frame Work

7.34.3.1 The metal frame work may be made of sections of light metal, such as anodised aluminium, mild steel or as shown on the drawings. The shape of cross-section shall be such as to facilitate proper suspension and proper fixing of the ceiling boards covering them and shall be structurally sound and rigid.

7.35 Construction

a) Contractor shall ensure that the frame to support the ceiling is designed for structural strength and the sizes, weight and strength of ceiling boards to be fixed and other loads due to live load, air-conditioning ducts, grills, electrical wiring and lighting fixtures, thermal insulation, etc. as shown on the drawings. Contractor shall also submit a detailed drawing to show the grid work, sizes of grid members, method of suspension, position of openings for air-conditioning and lighting, access doors, etc.

b) Structural design of timber member for the frame shall be in accordance with IS : 883, and metal sections shall be of appropriate size and thickness and shall be of approved manufacture, all as approved by EMPLOYER.

c) The false ceiling grid work shall be carried out as per the approved drawings or as directed by EMPLOYER. In case of timber grid work, the grid work shall consist of teak wood runners of minimum size 60mm deep x 40mm wide along one direction at 1.2m centre to centre and secondary runners of size 50mm deep x 40 mm wide at 60mm centre to centre perpendicular to the main runners.

d) The timber grid work shall be suspended with the help of wooden hangers or metal hangers at 1.2m centre to centre in both the directions. Wooden hangers shall be adopted for flat R.C. roof slab structures whereas metal hangers for flat R.C. roof or structural steel floors / tresses. Metal hangers shall be fabricated from mild steel / galvanised flats of 35mm x 6mm size or bars of 10mm dia. Threaded at the lower end and anchored securely in the roof concrete or welded to inserts provided on the underside of slabs, beams etc. All M.S. hangers shall be given two coats of red oxide zinc chromate paint primer. In case the roof work is of A.C. sheeting supported on purlins and trusses, hangers shall be suspended from roof steel work. The arrangement of metal hangers shall be such that the level of false ceiling can be adjusted during fixing of the ceiling frame work. The ceiling frame work shall be secured to hangers by means of washers and nuts. The ends of main runners shall preferably be embedded into the masonry work.

e) The metal frame work when it is anodised aluminium false ceiling grid system shall consist of aluminium main member of special T-Profile of 38mm x 38mm x 1.5mm thick, interlocking with each other to form frames of various sizes, 600mm x 600 mm or as shown on the drawing. The main members shall be suspended from the roof structures by means of steel hangers as described for timber frame work and supported at the walls by means of anodised aluminium wall angles.

f) In the case of timber frame work, all the edges of the plaster of paris board shall be fixed to frame members by means of counter sunk and rust less screws of

2.74 mm size, 40mm long at a spacing of 100mm to 150 mm c/c and 12mm from the edge of the board. Holes for screws shall be drilled and screws slightly countersunk into the boards. The boards shall be fixed to wooden framework with a joint clearance of about 3mm. The joints shall always be in perfect line and plane.

g) In case of aluminium grid system, boards shall be just placed into the frames formed by the main `T' members and the cross members fitted with the clips for locking boards. Contractor shall take utmost care so as not to force the boards in position and a slight gap shall be provided so as not to make a tight joint. The boards shall be cut with a saw, if required, to any shape and size.

h) As the work of false ceiling may be inter-connected with the work of air-conditioning ducts and lighting, Contractor shall fully co-operate with the other agencies entrusted with the above work, who may be working simultaneously . Contractor shall provide necessary openings in the false ceiling work for air-conditioning, lighting and other fixtures. Additional framing, if required, for the above opening shall also be provided at no extra cost to Employer. Removable or hinged type inspection or access trap doors shall be provided at locations specified by EMPLOYER.

7.35.1 Finishing

7.35.1.1 It is essential that false ceiling work should be firm and in perfect line and level and all boards free from distortion, bulge, and other defects. All defective boards and other material shall be removed from site immediately and replaced, and ceiling restored to original finish to the satisfaction of EMPLOYER.

7.35.1.2 The workmanship shall be of highest order and all joinery work for timber work shall be in the best workmanship manner. The joints for aluminium frame work shall be of inter-locking type so that when the cross member is in place, it cannot be lifted out.

7.35.1.3 The countersunk heads of screws and all joints shall be filled with plaster of paris and finished smooth. After filling the joints, a thick skin of the finishing material shall be spread about 50mm wide on either side of the joint and on to it shall be trowelled dry a reinforcing scrim cloth about 10mm wide. If metal scrim is used, a stiffer plaster will be necessary to enable the trowelling of the scrim down to the board.

7.35.2 Fire Stopping

7.35.2.1 In case of fire protective ceilings, fire resisting barriers at suitable intervals shall be provided. These shall completely close the gap between the false ceiling and soffit of the structural slab. The material of the barrier shall be as indicated by EMPLOYER (Reference may be made to the British Standards Institutions CP 290: Code of Practice for suspended ceiling and lining of dry construction using metal fixing system, `for guidance).

7.36 False or Cavity Floor

7.36.1 Frame Work

7.36.1.1 The false floor shall consist of a framework of suitable structural member designed to carry the loads specified. This frame work shall be supported on suitably designed stools placed at 600mm centre to centre in both directions. The stools shall consist of a mild steel base plate with a mild steel stud having adjustable lock nut and coupling at the centre and another mild steel plate at top serving as a prophead. The above framework shall be suitably designed to accommodate 35mm thick, 600mm square panels. The base plate shall be fixed to the reinforced concrete floor with an approved adhesive compound or with 4 Nos. 6mm dia. anchor fasteners. Bedding of 1:2 or richer cement sand mortar shall be provided locally under the base plates of stools to provide a level surface.

7.36.1.2 The prophead shall be provided with mild steel lugs welded on top and each placed perpendicular to the other for proper positioning and supporting the main and cross members. The stools shall be capable of adjustment to accommodate concrete floor level irregularities upto plus or minus 15mm. The framing members shall be completely removable and shall remain in position without screwing or bolting to the propheads. All steel framework including steel stools shall be given a coat of zinc chromate primer and two coats of enamel paint of approved colour and shade.

7.36.2 Floor Panels

7.36.2.1 The floor panels shall be made of 600mm x 600mm x 35 mm thick medium density unveneered/ non-prelaminated teak wood particle boards having a density of not more than 800 kg/cu.m bonded with boiling water proof phenol formaldehyde synthetic resin and shall be of fire resistant, termite resistant and moisture proof quality, generally conforming to IS:3087-specification for wood particle boards (Medium Density)for general purposes.

7.36.2.2 The thermal conductivity of the boards shall not exceed 0.12 kCal/hr/sq.m/deg./C/m.

7.36.2.3 The panel size given above may be suitably modified near electrical panel/equipment and also to suit room dimensions with panel size not more than 600mm under any circumstances. Exposed 2mm thick vinyl edging shall be provided on all edges of individual panels. Each panel shall be given a coat or primer and two coats of approved fire resistant paint from underside.

7.36.2.4 The particle boards shall be faced with 600mm x 600 mm x 2mm thick approved make flooring tiles conforming to IS:3462 – "Specification for unbacked flexible PVC flooring" and of approved colour and shade. The completed panel shall be completely removable and shall remain in position without screwing or bolting to the on the inner side with stickers for easy identification and reassembly whenever required.

7.36.2.5 Suitable backing material shall be provided on the underside of the particle board to prevent warping and / or to cater to specified loading.

7.36.2.6 Suitable removable covers shall be provided to serve as outlets for the cables.

7.36.3 Imposed Loading

7.36.3.1 The finished floor shall be capable of supporting a uniformly distributed load of 500 to 1000 Kg. per sq.metre of floor area as specified in data sheet. A point load of 450 Kg on 600 sq.mm on any part of the panel or a line load of 725 Kg on 100mm strip across the panel length shall not result in a deflection greater than 2.5mm.

7.36.4 Finish

7.36.4.1 The finished floor shall be true to lines and levels and present a neat flush surface.

7.36.5 Vendor Drawing

7.36.5.1 Vendor shall prepare and submit a layout drawing for false floor giving all details including supporting system for approval. If so called for, vendor shall also submit his calculations for the supporting system with all relevant data assumed, to the EMPLOYER for his approval. Work shall be carried out on approved drawings only.

7.37 Fire Proof Doors

7.37.1 Material and Workmanship

7.37.1.1 The design of fire proof doors and the materials to be used in their fabrication have to be such that they shall be capable of providing the effective barrier to the spread of fire. The materials, fabrication and erection of fire proof doors shall confirm to IS:3614 (Part – I). The fire proof doors shall be obtained from an approved manufacturer. Specific approval for such purchase shall be obtained before hand. Sample approval shall also be obtained from testing authority as per the standard IS : 3614 (Part – 2) for the specified degree of fire rating in hours. All fire proof doors shall have specified sizes and confirm to the description in the respective items of work.

7.37.1.2 Fire proof door shutters shall be of zinc coated weldable steel (confirming to BS:6687) or stainless steel (conforming to IS:304) sheet (18G minimum) fixed in a frame work of rolled channel. The shutter shall consist of an insulating material like mineral wool in required thickness to satisfy the specified fire rating. Normally the thickness of door shutter shall not be less than 35mm for two hour fire rating and 46 mm for four hour fire rating.

7.37.1.3 The shutter with the required insulating material shall be mounted on angle iron frame or the special made frame from zinc coated (16G minimum) weldable steel sheet. The shutter shall be fixed to frame by means of suitable hinges and shall have a three way latching system. All the doors shall be provided with a coat of primer and one coat of synthetic enamel paint to attain the specified fire rating. All other accessories like hinges, door lock, hold fasts, etc. shall be provided as approved by TAC (Tariff Advisory Committee). All these accessories shall be compatible with the material used for door and shutter.

Applicable codes

The following codes and standards unless specified herein shall be referred to.

Materials

IS	:	210	Specification for grey iron casting
IS	:	290	Specification for coal tar black paint
IS	:	456	Code of practice for plain and reinforced concrete
IS	:	458	Specification for pre cast concrete pipes (with and without reinforcement)
IS	:	516	Method of test for strength of concrete
IS	:	638	Specification for sheet rubber jointing and rubber insertion jointing
IS	:	783	Code of practice for laying of concrete pipes
IS	:	816	Code of practice for use of metal arc welding for general construction in mild steel
IS	:	1367	Technical supply conditions for threaded steel fasteners
IS	:	1387	General requirements for the supply of metallurgical materials
IS	:	1500	Method for Brinell hardness test for metallic materials
IS	:	1536	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS	:	1537	Specification for vertically cast iron pressure pipes for water, gas and sewage
IS	:	1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage
IS	:	1916	Specification for steel cylinder pipes with concrete lining and coating
IS	:	2078	Method for tensile testing of grey cast iron
IS	:	3589	Specification for MS Spirally Welded Pipes
IS	:	3597	Method of tests for concrete pipes
IS	:	3658	Code of practice for liquid penetrant flow detection
IS	:	5382	Specification for rubber sealing rings for gas mains, water mains and sewers
IS	:	5504	Specification for spiral welded pipes
IS	:	6587	Specification for spun hemp yarn
IS	:	7322	Specification for specials for steel cylinder reinforced concrete pipes
IS	:	8329	Specification for DI pipes
IS	:	9523	Specifications for DI fittings
IS	:	4984	Specifications for HDPE pipeline
IS	:	14846	Specifications for valves

Code of Practice

IS	:	783	Code of practice for laying of concrete pipes
IS	:	3114	Code of practice for laying of cast iron pipes
IS	:	3764	Excavation work - Code of Safety
IS	:	4127	Code of practice for laying of glazed stoneware pipes
IS	:	5822	Code of practice for laying of electrically welded steel pipes for water supply
IS	:	6530	Code of practice for laying of asbestos cement pressure pipes.

Pipe Work

The pipe works for the plant involves manufacturing, supplying, laying and jointing of suitable size cast iron, ductile iron pipes along with matching special etc as required. All piping inside the plant shall be cast iron/ductile iron except for chemical house and chlorine piping. The specifications for manufacturing, supplying, laying and jointing of pipes shall generally conform to the standard specification.
All pipe work and fitting shall be of 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 other major items of equipments. CI dismantling joints which can take radial and axial misalignment of minimum 1 percent of valve nominal size with 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 unions shall be fitted in pipe work runs, wherever necessary, to permit the simple disconnection of flanges, valves and equipment.

The Contractor shall be responsible for ensuring that the internal surface of all pipe work is thoroughly clean before and during erection and before commissioning. Cleaning shall include removal of all dirt, rust, scale and welding slag due to site welding. Before dispatch from the manufacturers' works, the ends of the pipe, branch pipe etc., shall be suitably be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small bore pipes shall be blown through with compressed air before connection is made to instrumental 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 the Engineer-in-charge.

Materials for Pipelines

Each pipeline shall be constructed in a material compatible with the fluid conveyed through that pipeline i.e. the materials used in the pipes which are or can be in contact with the untreated sewage, suitable additive for mortar protection shall be provided.

Pipework and valve materials for the following duties shall be as follows or equivalent to the approval of the Employer's Representative:

CAST IRON PIPING

Supplying lowering, laying to line, level and slope, centrifugally cast iron (spun) pressure pipes (LA Class strictly confirming to IS: 1536 (1989) with latest amendment) and jointing with specials such as Tees, Bends, Reducers including and other safety provision, cutting the pipes and making joints and hydraulic testing after laying etc. complete.

The CI pipes shall be LA Class conforming to IS: 1536 (1989) with latest amendments bearing ISI Mark.

The pipes shall be free from the defects resulting from raw materials, loading, handling, carting and unloading. The pipes shall be free from load, bents or bulges greater than 3mm in depth and extending over a length in any directions greater than twice the thickness of barrel.

Each lot of pipes supplied by the contractor must be accompanied by the test certificates as specified in IS: 1536 (1989) with latest amendments. The contractors shall have to make arrangement for inspection/testing of the pipes at manufacturers' factory at contractor's own risk and cost.

Each pipe shall have cast, stamped or indelibly painted on it the following marks.

a) Manufacturer's name or identification mark.
b) The nominal diameter.

c) Class reference.
d) The last two digits of the year of the manufacture.
e) IS Certification mark / Manufacturing Standard. For CI socket & Spigot pipes IS Certification mark is must.

The materials shall be carted to the site by the contractor very carefully. The handling, while carting the pipes, specials, valves etc. shall be done carefully.

In case of heavy pipes, specials etc. lowering shall be done with the help of the chain pulley block.

Caulking

After a section of convenient length has been leaded, caulking shall be commenced. The lead shall be free from the leading pipe, outside of the socket of the other pipe with flat chisel, and then caulked round 3 separate times with the proper caulking tools of increasing thickness and hammer 4 to 5 lbs. in weight in such manner as to make the joints sound and water tight.

Joints under water shall be made with lead wool inserted in strings not less than 6 mm thick and very throughly caulked.

New Flanged Joints

Flanged joints should be made by painting the facing of the flanges with red lead freely and belting up evenly on all sides.

A thin fiber, of lead wool may be very useful in making the joints water tight, where facing of the pipes is not true.

Where packing must be used, it should be of rubber insert cloth three ply and of approved thickness. The packing should be of the full diameter of the flange with proper pipe hole and bolt holes cut and even at both inner and outer edges.

Where the flange is not fully faced, the packing may be of the dimension of the facing strip only. Its proper placing should be tested before another pipe is jointed on.

Testing

After each section of the pipe line has been completed, it shall be tested for water tightness before being covered in. This can be done by closing each end by means of a reliable gauge. When the pipe is laid on any appreciable gradient, the test should be carried out at the lower end of the section. Any leaking joints should be made good, and the above test reapplied until no further leaks are apparent.

Tyton Joints

After the pipes are examined for line and levels, the CI pipes shall be jointed with rubber gaskets (tyton joints) as follows.

The socket and spigot end shall be cleaned with kerosene oil, then grease has to be applied to the spigot and socket ends, duly after inspection of rubber gasket. Then the rubber gasket shall be jacked and fixed in perfect condition such that the gasket will fall in groove correctly and the joint become water tight.

Tyton/Lead jointing shall be carried out after the CI pipes and specials are properly laid and approved by the Engineer-in-charge.

The lead shall be more than 99%. It shall be soft bluish grey pig lead free from admixtures of tin or other impurities. The lead shall confirm to the IS: 3114 (1965).

The spun yarn shall be clean hemp and soaked in hot tar or bitumen, cooled and dried before use.

The outside of the spigot and the inside of the socket shall be thoroughly cleaned with a brush. The spigot shall be carefully centered in the socket by spun yarn twisted into ropes of uniform thickness. The rope shall be well caulked in to the back of the socket to leave a sufficient depth for lead as directed by Engineer-in-charge. The lead shall be used as specified in Table-1 of IS: 3114 (1965).

The proper depth of each joints shall be as specified and tested before running the lead by passing completely around it a wooden gauge notched out to the correct depth of lead.

The leading of joints shall be done by means of ropes covered with clay or a by using special leading rings. The lead shall be melted rendering it thoroughly fluid and each joints shall be filled in one pouring.

After a section of convenient length has been leading pipe outside of the socket of the other pipe, with a flat chisel and then caulked round three separate time with the proper caulking tools of increasing thickness and hammer 2 to 3 kg weight in such a manner as to make the joints sound shall be left flush neat and even with the socket.

The item includes all materials tools, tackles etc. required to carry out the work including fire wood etc.

After each section of the pipe line has been completed it shall be tested for water tightness. The ends shall be suitably closed with a valve, cap or plug or a blank flange. The pipe line shall then be filled with water, pressure shall then be supplied with a hand force pump up to 7 kg./sq.cm. (Above 100 lbs./sq. inch.) Or 15% above. If the pipe is laid on an appreciable gradient, the test shall be carried out at the upper end of the section.

Any leaking joints shall be made good and the test repeated until a perfectly leak proof pipe line obtained.

Consumption of lead for jointing of pipe lines:

The purity of lead must be more than 99% and the contractor shall have to furnish the test certificate and get approval from Engineer-in-charge. The consumption of lead and the depth of jointing shall be as per table listed below:

Sr. No.	Dia. of pipe line for joint in mm	Consumption of lead in kg.	Depth of lead joint in cm
1	80	1.86	5.00
2	150	3.62	6.00
3	200	5.00	6.00
4	250	6.12	7.75
5	300	7.70	8.00
6	350	10.45	8.12
7	400	11.20	8.25
8	450	14.30	8.40
9	500	16.25	8.50
10	600	19.00	9.15
11	700	21.00	10.00
12	800	31.50	10.50
13	900	41.00	10.50

Hydraulic Test

It shall be incumbent upon the contractor to give a successful hydraulic test of each and every pipe line before filling of the trench. The test shall be carried out in the approved manner by an approved testing machine and pressure gauge to be supplied by the contractor. All the arrangements for such a test should be made by the contractor at his cost including filling the pipe with water etc. and giving a successful hydraulic test.

Testing of the pipe line in the field shall be carried out after the completion of whole length or in parts as directed by Engineer-in-charge. The trenches shall be partially refilled except at the joint before starting the test. In each case, the contractor has to plug the both ends of the section of pipeline to be tested either by providing caps or by sluice valves as per direction of Engineer. No extra payment will be made for providing, fixing and removing caps used for testing purpose. If necessary, both the ends shall be properly anchored by providing 1:3:6 c.c. blocks of required dimensions. Contractors shall provide required number of plug points with ferrules of required diameters to serve as injection points, air relief points etc. No payment shall be made for this work. On the completion of the test these points shall be closed by plugs by the contractors without any extra cost.

Testing will be carried out by the contractors under the guidance of Engineer-in-charge. Contractors shall arrange for required machinery, equipments and technical staff for testing the pipe line. Contractors shall also arrange for labourers, other materials and tools required to attend the leakage etc. during the test.

The pipe line shall be subjected for following tests.

Leakage Test

The test shall be conducted after satisfactory completion of the pressure test.

There shall not be any leakage in the pipe or at the joint. A seepage allowance of a 2.5 litres per kilometer per hour per centimeter diameter of the pipe shall be permissible and that quantity will not be considered as leakage.

If the retest is delayed for more than 48 hours after any test has proved unsuccessful the Engineer-in-charge, after giving 24 hours notice, shall have every right to get all defects rectified and carry out other necessary works and take hydraulic test/leakage test to the contractor. Any damage done to the pipes, materials, the other labour cost, etc. incurred there under shall be recoverable from the contractor either from his bill or deposit.

The responsibility of the contractor as specified above in case of unsuccessful hydraulic test shall not cease to exist by his pleading that any materials used by him in the pipe line was having cracked or was otherwise defective, as if he has a reason to believe so, he must refuse to accept such materials right at the stores.

If the first test is not found satisfactory, repeated tests will be taken and procedure mentioned above should be followed for testing till a satisfactory test is given. All testing shall be done at the risk of the contractors and they have to attend be done at the risk of the contractors and they have to attend all defects including repairing bursts, leaks at joints, sluice valve ends, caps etc. removing and replacing cracked pipes etc. These unserviceable articles shall be the property of the contractors and they shall arrange to remove the same from the site as directed by the Engineer.

Any portion of the pipe line that does not stand the specified pressure, shall be rectified by the contractor, who should make his own arrangement for the water required for the testing.

When the section of the pipe line is tested successfully the contractor shall remove the blank flanges, pump out water from the pipes and back fill the portion as per directions of the Engineer.

CI Double Flanged Pipes/Piping within pump house shall be tested for 150% of maximum system pressure.

The items include all materials and labour required to carry out the work as detailed above.

CAST IRON FITTING AND SPECIAL:

Supplying at site of work CI fittings/specials confirming to IS: 1538 (1993) with latest amendments.

The contractor shall have to procure required cast iron specials such as Tees, Bends of required degrees, reducers, collars, caps, plugs and tail pieces etc. necessary for completion of this item as per site conditions.

The CI fittings and specials shall conform to IS: 1538 (1993) with latest amendments.

The fitting shall be stripped with all the precautions necessary to avoid warping or shrinking defects. The fitting shall be free from defects other than any unavoidable surface imperfection which results from the method of manufacture and which do not affect the use of the fittings.

The fittings shall be such that they could be cut, drill or machine.

The mass of CI fittings/specials shall strictly conform to IS: 1538 (1993) with latest amendments.

The contractor shall have to procure the required CI fittings or specials as per the site conditions and as per direction of Engineer-in-charge.

DUCTILE IRON PIPES and FITTINGS:

Pipes and Fittings

(a) General

Ductile iron pressure pipes (up to Class K9) shall comply with IS: 8329. For flanged pipe flanged end shall be welded on flanged pipe and pipe shall be min. K9 class.

Ductile iron pressure fittings (up to Class K12) shall comply with IS: 9523. For flanged fittings flanged end shall be welded on flanged fitting.

All fittings shall be socketed unless specified except for incoming and outgoing below unit shall be flanged.

(b) Materials

The materials used in the manufacture pipes shall comply as per IS:8329 and for fittings shall comply as per IS: 9523.

(c) Tests

Tests on pipes shall be carried out in accordance with IS:8329 and on fittings shall be carried out in accordance with IS: 9523.

Testing of Pipe

The main test among others to be conducted shall be as per IS: 8329 (2000) or with its latest revision/amendments.

(A) Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes as specified in the Standards. The frequency and sampling of tests for each batch of pipes shall be in accordance with IS: 11606 (1986). The test results so obtained for all the pipes and fittings of different sizes shall be submitted to Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per IS: 8329/EN 545 for pipes and IS: 9523/EN 545 for fittings.

(B) Brinell Hardness Test

For checking the Brinell hardness the test shall be carried out on the test ring or bars cut form the pipes used for the ring test and tensile test in accordance with IS:1500. The test shall comply with the requirements specified in IS: 1500/ISO 6506.

(C) Re-tests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in the standard for a period of minimum 15 seconds during which the pipes shall be struck moderately with a 700gms hammer for conformation of satisfactory sound. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before surface coating and lining.

Quality Assurance

The manufacturer shall have a laid down Quality Assurance Plan for the manufacture of the products offered which shall be submitted along with the tenders.

The Employer's representative shall be permitted free access to the place of manufacture for the purpose of examining and witnessing the testing of pipes and fittings.

Joints

(a) Spigot and Socket Joints

These shall have sockets which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS:12820 suitable for carrying raw sewage with high septicity.

EPDM Rubber Gasket

Rubber Gasket shall be suitable for Push-on-Joint on lines carrying septic sewage.

The spigot ends shall be suitably chamfered or rounded off to facilitate smooth entry of pipe in the socket fitted with the rubber gasket. Rubber Gasket shall confirm to IS: 5382 and ISO 4633-1996 or its latest revision or amendments if any. Rubber ring bundles form every lot shall carry with them manufacturers test certificate for the following mechanical properties

Hardness

Tensile strength
Compression set
Accelerated again test
Water absorption test
Stress relaxation test

Rubber rings shall be clearly labeled in bundles to indicate the type of ring, the type of joint, the size Rubber rings shall be clearly labeled in bundles to indicate the type of ring, the type of joint, the size of the pipe with which they are to be used, the manufacturer's name and trade mark, etc. such other required details.

(b) Flanged Joints

The flanges shall comply with dimensions and drilling details in IS: 8329 for applicable class. All flanged joints between steel and ductile iron pipe work shall be electrically isolated joints.

These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts.

Linings

Ductile iron pipes and fittings shall have a cement mortar lining, in accordance with IS: 11906 or ISO 4179.

Pipe linings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Employer's representative. The Contractor may use specialist mortars, mortar additives or curing agents only with the approval of the Employer's representative.

Certain sections are amplified as follow:
For sewage & industrial effluent application Sulphate Resistant Cement shall be used as specified below for internal lining requirement and no other additive shall be used without the written approval of the Employer's representative, and shall be used strictly in accordance with the manufacturer's recommendations.

The minimum thickness of the lining at one point shall not be less than 4mm.

Internal Lining

Internally pipe shall be Cement mortar lined as per IS: 8329 / IS: 11906.Ductile iron pipes and fittings shall normally have a portland cement mortar lining. However, for Sewage and Industrial effluent lining shall be Sulphate Resisting Cement Mortar Lining.

Cement mortar lining shall be applied at the pipe manufacturing shop in conformity with the aforesaid standards.

Pipe lining shall be inspected on site and any damage or defective areas shall be made good to the satisfaction of the Engineer. Lining shall be uniform in thickness all along the pipe. The minimum thickness of factory applied cement mortar lining shall be as per IS: 8329 Annexure-B or ISO 4179. This is given below.

Nominal Pipe Size (mm)	**Nominal lining thickness (mm)**
Up to 300	3
350-600	5
700-1200	6
1400-2000	9

Coating

Pipe shall be delivered internally and externally coated.

External Coating

Pipe shall be metallic zinc coated and after that it shall be given a finishing layer of bituminous paint as per IS: 8329 (2000). Zinc coating shall comply with IS: 8329/EN 545/ ISO 8179. Only molten zinc spray coating shall be acceptable. The average mass of sprayed metal shall not be less than 130 g/sq. m with a local minimum of 110 g/sq. m.

Bitumen overcoat shall be of normal thickness of 70 microns unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 3416 Type II suitable for tropical climates factory applied preferably through an automatic process.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

(a) General

Ductile iron pipes and fittings shall be zinc coated with a bitumen over coating, all in accordance with the following Specifications. Buried pipes and fittings shall also have a site or factory applied polythene sleeving. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Employer's representative.

(b) Zinc Coating

Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m^2 as described in Clause 5.2 of ISO 8179.

(c) Bitumen Coating

Bitumen coating shall be of normal thickness 0.07mm unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

(d) Polythene Sleeving

Where polythene sleeving is specified to be applied in addition to bitumen coating it shall comply with ISO 8180. Site applied sleeving shall be stored under cover, out of direct sunlight, and its exposure to sunlight shall be kept to a minimum. Pipes having a factory applied sleeving must be stored in the same conditions.

CEMENT CONCRETE PIPES

Design

Design of Cement Concrete pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458 (2003).

Manufacturing

(a) General

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 rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

The Employer's representative 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 Employer's representative if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Employer's representative.

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

(b) Materials

(i) 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.

(ii) 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.

(iii) Mixing and Curing Water

Water shall be clean, color 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.

(iv) 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.

(v) 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 15cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

(c) 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.

(d) Workmanship and Finish

Pipes shall be straight and free from cracks except that craze cracks may be permitted. 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 3mm in pipes up to 600mm diameter (inclusive), and 6 mm in pipes larger than 600mm 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 Employer's Representative 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 3mm 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 3mm for every meter run.

(e) 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.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Employer's representative 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 Employer's representative 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

(f) Sampling and Inspection

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 r the pipe be selected till the requisite number is obtained, r 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 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.

(g) Marking

The following information shall be clearly marked on each pipe.

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

Jointing

(h) General

Jointing of RCC pipes shall be done as per the following Employer's requirements and as per the relevant IS. 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.

(i) Spigot and Socket joint (Rigid)

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.

(j) Collar Joint (Rigid)

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 Employer's representative 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, 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 450 to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Employer's representative. 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.

(k) Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900mm diameter and over.

The ends of the pipes are specially shaped to form a self centering joint with an internal jointing space 13mm 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.

(l) 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.

(m) 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 in to 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.

(n) 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 into the remaining annular space and rammed with a caulking tool.

(o) 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.

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 Employer's representative, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Employer's representative to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Employer's representative 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 Employer's representative.

It shall also be ascertained by contractor that each stretch from manhole to manhole or the stretch as directed by Employer's representative 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.

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 Employer's representative. 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 Employer's representative. 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 Employer's representative 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 Employer's representative. Contractor if required by the Employer's representative 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 meters/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.

Support of Pipe work and Accessories

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipe work shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Employer's representative.

After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure will be made good by the Contractor.

Storage and Shipment

Protection of Pipes and Fittings for Shipment

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturers' works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

Storage of Pipeline Materials

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500mm diameter or over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Employer's representative and in accordance with the manufacturers' instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

Transportation of Pipes and Fittings

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturers' recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Employer's representative may cause damage to the pipes shall be discarded.

Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

Inspection of Pipes and Fittings

Before incorporating into the Works each pipe shall be brushed out and carefully examined for soundless. Damaged pipes which in the opinion of the Employer's representative cannot be satisfactorily repaired, shall be rejected and removed from Site. Damage to pipe coatings or linings shall be repaired to the satisfaction of the Employer's representative.

Built-in Pipe Work and other Plant

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipe work and other Plant is in accordance with the requirements of the programme.

Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall be to BS 4504 but shall be undrilled. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

Unplasticised PVC Pipes and Fittings

Unplasticised polyvinyl chloride (UPVC) pipes, fittings and specials shall be to BS 3505 / IS:4985:2000 Class-5 and minimum Schedule 40 for potable water and BS 4346: Part-1 for fittings. The pipes shall be of the spigot and socket type PVC pipes, fittings and specials are to be connected to cast iron, DI, stainless steel or steel pipes by suitable type flange adaptors or stepped couplings shall be used.

Rubber Hosing

Rubber hosing shall conform to BS 5119, Type 2. It shall be capable of handling a working pressure of 12 bars.

HDPE Pipes

The item shall be covering manufacturing, supplying, and delivery of HDPE pipes having pressure rating PN 10 and material grade PE-80/PE-100 bearing IS: 4984 (1995) and its latest version or amendments. The HDPE pipes shall be supply in standard length or as per owner's requirements.

Standard

The HDPE pipes is to be procured, supplied under the scope of this item and which shall be meet the requirement of pressure rating of PN 6 /PN 10 and material grade PE-80/PE-100 in accordance and confirming to IS: 4984 (1995) or its latest version or amendments with IS certification mark.

Temperature Variation

All the pipes to be supplied and delivered shall be subject to weather condition like sun, dust, rain and wind as available in the state of Gujarat. They shall also be subject to carry and convey drinking water under available temperature condition ranging from 4 ^{0}C to 40 ^{0}C.

Marking

The method of marking to all the pipes to be used under the scope of contract shall ensure that all the information as mentioned in clause 10 of IS: 4984 (1995) and/or its latest amendments. The marking will remain legible even after transportation, storage in open space etc. In general the legible and indelible marking upon the pipes shall indicate the following:

a) Manufacturer's name or trade mark.
b) Type / Grade of material.
c) Class of pipes / pressure rating.
d) Nominal diameter.
e) Manufacturing Standard .
Any other important matter that the manufacturer of purchaser deems fit to be inscribed.

Push fit joints shall be used for joining of pipes. These fittings shall carry the necessary international approvals for leak proof jointing.

100 % virgin material only shall be used and no rework/recycled material is to be used for the production of pipes.

Inspection of Joints

The visual inspection of each joint should be done to ensure correct bead formation. Weld joint should be checked for axial alignment of welded pipes.

UPVC PIPES

uPVC pipes made of unplasticized polyvinyl chloride shall be confirming to IS:15328 with socket(s) suitable for elastomeric sealing ring type joints for conveyance of water under pressure. The pipes are intended to be used for buried water mains with ambient atmospheric temperature reaching up to 45 ^{0}C and soil surface temperature rising more than 65 ^{0}C. The stipulations given in this document for uPVC pipe which are not covered by any other code/standard, shall be governed by the provisions of IS: 4985. The pipes will be supplied with plain ends or one end plain with chamfer and other end socket suitable for elastomeric sealing ring type joints in accordance with IS: 4985 as per requirement.

Material
The material from which the pipes are made shall consist substantially of unplasticized polyvinyl chloride conforming to IS: 10151, to which may be added only those additives 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 pressure rating of pipes shall be of class-3 and class-4 in accordance with IS: 4985 with a maximum continuous working pressure at 27 ^{0}C of 6 and 10 kg/cm^2.

Dimensions of Pipes and Sockets

The dimensions and tolerances of pipes shall comply with IS: 4985. The tolerance on outside diameter and wall thickness of pipe shall be as per Table given in IS: 4985. The dimensions of the socket for elastomeric sealing ring type joint shall be in accordance with IS: 4985. The pipe shall be supplied in straight lengths of 6m with tolerance of + 20mm and - 0mm. The effective length of socket pipe shall be considered as shown in IS: 4985.

Physical and Chemical Properties

The pipe shall confirm to the clause 10 of IS: 4985 (2000) for its physical and chemical properties except for the density and ash content provisions which shall be as per the stipulations made above. The colour of the pipes shall be dark grey. Influence on water intended for human consumption shall be governed by IS: 12235. All plastic and non-plastic material for components of the uPVC piping system e. g. Elastomeric sealing ring, lubricants, when in permanent or in temporary contact with water which is intended for human consumption, shall not adversely affect the quality of the drinking water.

Mechanical Properties

The pipes and integral sealing ring will confirm to internal hydrostatic pressure in accordance with Clause 11.1 and sampling as per annexure D of IS: 4985.

Inspection

The pipes shall be offered for factory inspection and performance testing as per relevant standard if required by Purchaser/Client/Client's Consultant.

MS PIPES, SPECIALS/FITTINGS and FLANGES

MS Pipes

Fabricate, test, paint and supply of MS pipes of specified ID/OD and wall thickness conforming to IS: 3589 (2001) /IS: 1239 (1990). The pipes up to 150mm shall confirm to IS: 1239 with latest amendments of required class. The pipes of 200mm and above shall confirm to IS: 3589 Fe410 with latest amendments.

Tolerances on Outside Diameter of Pipes shall confirm as per IS:3589:2001.

Ovality shall not exceed 1 percent of the specified outside diameter for pipes having diameter to thickness ratio not exceeding 100 as per IS:3589:2001

Quality of Steel

Pipes shall be fabricated from steel plates conforming to IS: 2062 E250 BR and IS: 10748 Gr 3.

Thickness of Pipes

The pipe shall have minimum specified wall thickness as mentioned in IS:3589:2001 or as per Table-5 below, whichever higher.

TABLE - 5

MINIMUM SPECIFIED THICKNESS OF PIPES

Nominal Size (mm)	Minimum Specified Thickness of pipe in mm Up to 150NB Heavy IS: 1239 Part 1 and From 168.8mm OD IS: 3589 of FE 410 Grade
Up to 300	: 4
above 300 to 500	: 5
above 500 to 600	: 6
above 600 to 850	: 7
above 850 to 950	: 10
above 1000 to 1500	: 12

Hydraulic Pressure Test

Each pipe shall be hydrostatically tested at the manufacturers' works before the pipe is coated, wrapped or lined at the manufacturer's work as per applicable standard.

The Hydraulic test pressure shall be the pressure calculated from the following formula, except that the maximum test pressure shall not exceed 5 Mpa.

$$P = \frac{2 \times S \times t}{D}$$

P = Test pressure
S = A stress in MPa which shall be taken as 40% of the specified minimum Tensile strength.
t = Specified thickness in mm and
D = Specified outside diameter in mm.

Test pressure shall be applied and maintained for sufficiently long time for proof and inspection.

Carbon Steel/MS pipe after installation at site with respective joints, piping shall be tested for joint tightness at 150 % of Maximum working/system pressure it is likely to subject to.

MS SPECIALS

Scope shall include providing, fabricating, testing and supplying/installing MS Specials suitable to MS pipes, valves and other fittings from steel plates. MS specials shall be confirming to IS: 7322/IS: 1538 dimensionally. MS specials and fittings shall be fabricated at site of work tested to specified test pressure and including providing flanges required, painting inside zinc epoxy coating and outside anti corrosive red oxide primer, coated with three coats of anti-corrosive water proof paint including freight, loading, unloading, carting, stacking as directed, and including all taxes, insurance etc. The sizes and types of specials shall be as per requirements taking into consideration in tender items like pumps, sluice valves, non-return valves, scour valves, expansion joints, dismantling joints etc.

Flanges

All MS flanges conforming to IS: 6392, PN 1.0 and their dimensions of drilling be in accordance with IS: 1538/IS: 6392 suitable for pressure 10 kg/cm^2 (specification for MS fittings for pressure pipes for water, gas and sewage) or its latest revision. The flanges shall be flat faced with off center bolt holes. Prior to manufacturing process, the contractor shall have to obtain approval of Engineer in charge for all sizes and types of flange drawings.

Galvanising

Hot dip zinc coated Mild Steel Tubes/Pipes and fittings shall be as per IS: 4736 (1986).

Inspection

The material shall be offered for factory inspection and performance testing as per relevant standards if required by Purchaser/Client/Client's Consultant.

MS SPIRALLY WELDED PIPES

Manufacturing, supplying, lowering and laying in position sleeve/swaged ended, outer coated, spirally weld MS pipes confirming to IS: 3589 (2001) including all type of necessary coping, welding, outer coating treatment with corrosion chloride resistant treatment of "corrocretive te" or 4mm thick pipe coat, inner lining, safeguarding, lightening, barricading, fencing, field welding and hydraulic test as per the detailed item specifications and as per the directives of the Engineer-in-charge.

Material

I. Spirally submerged arc welded pipes shall be manufactured from steel produced by the open hearth or electric or one of the basic oxygen process.

II. Steel to be used in manufacture of spiral welded pipe shall be conforming to IS: 2062 (1992) and its latest amendments. Steel should be of Grade B, designated as Fe 410 in IS: 2062 (1992).

III. Sampling of pipes shall be as per IS: 4711 (1994).

Manufacture

The pipes shall be manufactured from steel strips by spirally submerged arc welding as per IS: 4353. The weld must be automatic and continuous. All the edges of the plates/ strips should be prepared suitable prior to the welding of pipes. Welding joints and its manufacturing process shall conform to IS: 3589 (2001). Weld consumable for SAW shall be as per IS: 814, IS: 3613, IS: 6419 and IS: 7280.

Length

The Client intends speedy as well as easy laying work of pipes procured through this tender. Accordingly, spiral welding pipes of all sizes shall be supplied in single random length from 5.50 meter to 6.50 meter. Pipes in such lengths shall be 90% of the total quantity. Remaining 10% (Maximum) pipes of the ordered quantity may have a length 10% shorter/longer in running meters to the length specified above.

Wall Thickness

Wall thickness shall be as per IS: 3589 (2001) without negative tolerance.

Finished pipes shall not deviate from straightness by more than 0.1% of the total length. Straightness shall be checked out by using a taut string or wire from end to end, along the side of the pipe to measure, the greatest deviation.

Hydraulic Pressure Test

Each and every pipe shall be hydraulically tested at manufacturers' works' at test pressure. Testing shall be carried out as specified in IS: 3589 (2001).

Mechanical Tests

I. Tensile Test

Tensile test shall be carried out as mentioned in IS: 1894 (1972) as well as IS: 3589 (2001). The tensile strength and percentage elongation of the pipes shall strictly conform to the provisions of IS: 3589 (2001). The Manufacturer shall submit the required test certificates at free of cost both for pipes as well as steel strips.

II. Guided Bend Test

Guided Bend Test shall be carried out as per the provisions of IS: 3589 (2001) and necessary test at free of cost for ERW pipes. Flattening test shall be as per IS: 1239/IS: 3589.

Other Tests

Radiographic testing or Ultrasonic testing in factory (15% of welded length of each pipe) as per IS: 3589 (2001). Radiography as per IS: 2595 ASME Section V Article 2 and 22. Ultrasonic test as per IS: 7343 ASME Section V Article IV.

Chemical Composition

As mentioned earlier the steel used for manufacturing shall strictly conform to IS: 2062 (1992) having grade designation Fe 410 WA. Chemical composition should be conforming to IS: 2062 (1992) and various constituents viz. Carbon, Manganese, Sulphur, Phosphorus, Silicon, Copper etc. shall be within prescribed permissible limits. The manufacturer shall submit the required test certificates at free of cost, both for pipes as well as steel strips.

Pipe Ends

I. All pipes shall have one end swelled and one end plain suitable for field welding. Both the edges of each pipe must be truly vertical. The swelled end shall be formed strictly as per the dimensions mentioned in IS: 3589 (2001).

II. The sleeve/swelled end of the pipes shall be formed in such a way that the plain end of the pipe shall be inserted inside freely/easily.

Mass

The mass of steel shall be 7.85 g/cm^3.

Workmanship

I. All pipes shall be clearly finished and when visually inspected shall be free from defects such as cracks, surface flaws, lamination etc. The ends of pipes shall be cleanly cut as mentioned in 7.0 and truly vertical with the axis of the pipe.

II. The copy of the ISI License for manufacture of pipes for the particular unit from where the pipes will be manufactured shall also be submitted.

III. Client intends to utilize pipes with two coats of Red Oxide as anti-corrosive primer. The pipes shall be supplied Oxide to avoid corrosion during monsoon period. The anti-corrosive primer shall be applied to the inside and outer side of the pipes.

Marking

Each pipe shall be legibly marked at free of cost with the following details.
(a) Manufacturer's name or trade mark.
(b) Outside diameter in mm.
(c) Wall thickness in mm.
(d) ISI mark.
(e) Purchaser's Name
(f) Last two digits of the year of Manufacture.

Field Welding

The welding and joint of the pipes in the field shall comply with IS: 816 (1965) and its latest amendments/IS: 9595.

The weld shall be run in three runs of welding. The welding and testing of the weld shall also be done as per the procedure laid down in IS: 823 (1964) and its latest amendments. Experienced welders whose

performance shall be tested from time to time, shall only be permitted to carry out the welding work. No apprentices or helpers shall be allowed to do any welding work, No apprentices or helpers shall be allowed to do any welding whatsoever. If any un authorised person is found to do welding work, he shall be removed from the work and the work carried out by him will have to be redone after gauging out the same. The following points shall be borne in mind by the contractors.

Electrodes

The contractors shall use standard AWS E7018 electrodes its number (i.e. type) depending on the thickness of plate and the type of joint. They shall also use standard current and voltage required for the machine in use. Electrodes be of ESAB India, ADVANI and D & H make only.

Electrodes to be used in welding work shall conform to IS: 814 and 815 and welding shall conform to IS: 816, 822 and 823. The electrodes must be of make "ESAB-INDIA", "Advani", "D&H" only.

Testing of Welded Joints

(i) General
The weld joints shall be tested in accordance with IS specifications IS: 823 (1964) and IS: 3600 (1973) or to its latest amendments.

The test pieces shall be taken out from the pipes pointed out by the Engineer without any delay. They shall be immediately delivered at the Engineer's Office for being numbered, machined and tested.

The shape of the test pieces removed from the pipes shall be such that It will give a specimen of the required dimension and at the same time leave a hole in the pipe with round corners. This hole shall be closed up by patch plating from the outside so as to have over lap of 3" on all sides of the opening. Great care shall be taken in preparing required MS plates for this, which is included in the item. After the jointing is completed all protruding portions shall be chipped off and the portion of the pipeline near the field joint shall be thoroughly scrapped and cleaned to receive the guinite.

(ii) Details Of Tests

The following test shall be carried out.

Tensile Test

The test specimen taken perpendicularly across the weld shall be shaped in accordance with the IS: 1663 (1962). The specimen shall be taken from the end of the pipe or at any joint in the pipe as directed by the Engineer and shall be cut with the weld approximately in the middle of the specimen. The tension test specimen shall be machined. The protruding welding portions from both inside and outside shall be removed by machining or grinding before the specimen is tested.

At least one field joint out of every 100 shall be subjected to test by taking out a specimen. If a test specimen shows defective machining or taking out a specimen. If a test specimen shows defective machining or develops flaws not associated with welding, it may be discarded and another specimen substituted.

The weld joint shall show a strength not less than the minimum tensile strength specified for the plate.

Bend Test

The bend test specimen shall be prepared in the same way as for tensile test and tested in the presence of the Engineer. The specimen shall be taken from the pipe selected for tensile test. The specimen shall

stand being bent cold through 180 degrees around a pin, the diameter of which is equal 4½ times the thickness of the plate without developing cracks. In making the bend test be placed next to the pin.

Outer Coating

Corrosion and chloride resistant treatment shall be carried out as specified below.

I. Prior to application of treatment, the pipe shall be made free from all mill scale, rust, foreign matters or any such materials must be removed from the pipe surface by use of wire brush followed by sand blasting to "SA 2 ½ standard immediately prior to the application of priming coating.

II. In addition, metal surface should be free from oil, grease and other impurities which can impair the adhesion.

In case of COROCRETIN_TE (i.e. thixotropic two component resin system with modified amine harder) layer, outer coating shall be carried out as below.

Prior to application of treatment, the pipe shall be made free from all mill scale, rust, foreign matters or any such materials must be removed from the pipe surface by use of wire brush followed by sand blasting to "SA 2 ½ standard immediately prior to the application of priming coating.

In addition, metal surface should be free from oil, grease, and other impurities which can impair the adhesion.

Application

I. Mix the individual components (Component A and Component B) separately with homogeneity. Mix one part of component A and one part of component B by weight thoroughly and apply using conventional brush, roller and spray.

II. Immediately after preparing surface by sand blasting apply one coat of Corocretine TE(S). Apply two more coats within the interval of 12 to 48 hours until the surface is completely free from pores.

Following care should be taken while application of this treatment.

i. Due care should be taken to prevent impurities and dampness on the surface in the time between the every application of treatment coat.
ii. If longer time is anticipated between topcoat, then the existing coat should be roughened before fresh coating is applied.
iii. After application of corocretin TE(S) should be protected from moisture (rain, dew, fog) for a period of 6-8 hours.

Consumption

For one prior coating and two topcoat each of 80 micron (total 240 micron) the consumption of Corocretin TE(S) shall be 750 gm/sm.

a) Painting near expansion joints internally and external paintings of patch plates.

b) For curing, depth of 20 to 30cm of water be maintained in the flat portion of the pipeline to maintain adequate humidity in the pipe required for curing.

c) Carrying out performance test for 'C' value.

Outer coating work, in case of "pypekot" Material shall be carried out as below.

1) All the mill scale, rust, foreign debris or any such material must be removed from the pipe surface by use of wire brush/power brush immediately prior to the application of primer on the surface of the pipe.

2) One coat of fibre coal tar and solvent based compatible primer of density 0.92 gm/cu mt. and viscosity of 1000 to 2000 CPS at 150 gm/sq. mt. shall be applied. The primer shall be allowed to dry until the surface becomes tacky. The primer shall be applied to dry until the surface become tacky. The primer shall be allowed to dry until the surface becomes tacky. The primer shall be applied to dry until the surface becomes tacky. The primer shall be applied in such a manner that it produces an effective bond between metal and subsequent coating of 4mm thick polymeric tape.

3) Tape may be wound either circumferentially or spirally with using thermo fusion process to completely adhere with primer coated surface maintaining minimum 15mm overlaps to the two adjacent layers. Cost of overlap is included in the item and no extra payment shall be done for it.

4) Either end of the pipe shall be left uncoated to enable proper installation/laying as well as field welding work. This area shall be coated in situ after the installation/laying and welding of the pipes in the trench. In case of any damage is occurred to the outer coating of the pipe during handling, laying and installation at any place of the surface, the rectification shall be done by patching up the damaged area by thermo-fusion at no extra cost.

5) Holiday test as described in IS: 10221 shall be conducted at the cost of the Contractor in the presence of an authorised representative of and if any fault/defect is found, it shall be rectified at no extra cost.

6) Cross adhesive test.

Inner Lining

This clause covers scope of material and application of cement mortar lining on the inside surface of the pipe line. The application of mortar lining covers lining of straight pipe sections, long, short radius bends, vertical shafts and all specials etc. the lining shall be carried out through an access by a machine that progress uniformly through an access by a machine that progress uniformly through the pipe and applies mortar against the pipe surface and Mechanically trowels it to obtain smooth lining of bends, specials and areas adjacent to valves shall be appropriately dealt with according to the best practice of the trade for the diameter concerned. The Contractor should specify what is the best practice and produce acceptable evidence therefore.

All access openings and feed openings or manhole for feeder hoses shall be re-welded in position after lining them. The line will be restored to the satisfaction of the owner.

The scope further includes mobilization of equipment, making access openings wherever required and curing of the mortar lined pipe including testing. Patching access holes etc. as described in following pages.

The main items of work will be generally as follows.

a) Mobilisation of equipment, plant and machinery.

b) Deciding access openings in the main and providing temporary access up to openings wherever necessary.

c) Making trenches of suitable depth, width and length for making access openings in case of underground (U/G) pipe including dewatering and refilling.

d) Breaking gunited/concreted surface (if any) of U/G pipe and cutting the top portion of pipe (Underground as well as above ground) to provide for access opening.

e) Provide necessary platform for installation of mixing machinery.

f) Remove and refit appurtenances, provide additional ventilation openings and plugs, if required. Take suitable measures for adequate ventilation in case of U/G pipes.

g) Maintaining the pipe temperature between $50\ ^0F$ and $90\ ^0F$.

h) Cleaning the pipe surface internally.

i) Mortar lining the internal surface of the pipe lines.

j) Curing the mortar lining.

k) Inspection and testing of mortar lining.

l) Hand lining with cement mortar for top and bottom portion of pipe removed for access opening. While at enter side it should be coated with 4mm thick thermo-fusible polymeric corrosion protection tape called "PYPE COAT" conforming to IS: 10221.

General Cement Mortar Lining Design

a) Composition

Mortar for the lining shall be composed of cement, sand and water that have been well mixed and are of such consistency as to produce a dense, homogenous lining. Unless otherwise specified by the Client, the mortar may also include admixtures as per IS: 3589 and IS: 11906 (1986).

b) Proportions

The approximate proportions of cement and sand in the mortar for the mortar for the lining shall be 1 part of Portland cement to 1 part of sand by volume.

The exact proportions shall be determined by the characteristics of the sand used. Admixtures, if added, shall be used in strict compliance with the Manufacturers recommendation.

The Contractor should specifically state as to the cement proportion to use having regard to his experience (to be stated) and the practice or specifications his principle follow generally and recommend in this particular case.

c) Water Content

The water content shall be IS: 456 the minimum quantity that produces a workable mixture, with full allowances made for moisture collecting on the interior of the pipe surfaces. Slump tests should be made periodically on freshly mixed mortar immediately prior to the mortar lining conveyed to the lining machine. The test results of slump test should indicate slump of Mortar required consistency or as per directives of the Engineer-in-charge. Each lot cube will be Taken and Tested as per IS: 3589.

Mortar shall be mixed long enough by machine to obtain Maximum plasticity. The mortar shall be used before initial set.

d) Field Test

The Slump test for compressive strength of mortar shall be carried out by the Contractor for determining the Quality of mortar.

e) Thickness of Lining

The lining shall be uniform in thickness within the allowable tolerance, except at joint or deformations in the pipeline. Cement mortar lining thickness shall be 9.5mm. The tolerance for lining shall be + 2.5mm for pipe and + 5.0mm for specials with no minus tolerance, the mortar lining work shall be by single application.

Laying of Pipes

Carting and Handling

Pipes and fittings/specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the Employer's representative. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or swelling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5m.

Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

Laying

f) Laying of Pipes and Fittings/Specials

All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure/pipeline of water, gas, sewage etc. After excavation of trenches, pipes shall not be lowered unless the dimensions of trenches and bedding work for pipes at the bottom of the trenches are approved and measured by Employer/Employer's representative. Pipes and fittings/specials shall be carefully lowered in the trenches. Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings/specials shall be made by Contractor. In no case pipes and fittings/specials shall be dropped. Slings of canvas or equally non-abrasive material of suitable width or

special attachment to fit the ends of pipes and fittings/specials shall be used to lift and lower the coated pipes and fittings/specials. The pipes and fittings/specials shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. If doubt persists, further confirmation shall be done by pouring a little kerosene/dye on the inside of the pipe at the suspected spot. No sign of kerosene/dye should appear on the outside surface. Pipes and fittings/specials damaged during lowering or aligning shall be rejected by the Employer's representative.

All the pipes are to be laid perfectly true both in alignment and to gradient specified. In case of spigot and socket pipe the socket end of the pipe shall face upstream, except when the pipeline runs uphill in which case the socket ends should face the upgrade. The laying of pipes shall always proceed upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket. Pipes and fittings/specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings/specials of proper dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Employer's representative. During the period that the plug is on, the Contractor shall take proper precautions against floating of the pipe owing to entry of water into the trench. Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted the deflection allowed at joints shall not exceed 2 ½0. In case of pipes, with joint to be made with loose collars, the collars shall be slipped on before the next pipe is laid. The pipes shall be laid such that the marking on pipes appears at the top of the pipes in case of flexible joints only

The cutting of pipe for inserting valves, fittings, or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

g) Thrust Blocks

Thrust blocks shall be provided, to counteract hydraulic thrust, at places wherever directed by the Employer's representative especially at horizontal and vertical bend.

h) Jointing

Jointing for pipes and fittings/specials shall be done in accordance with the relevant Employer's requirements depending upon the type of pipes being used.

i) Testing and Commissioning

Testing and commissioning of pipes shall be done in accordance with the relevant Employer's requirements.

Carbon Steel/MS pipe after installation at site with respective joints, piping shall be tested for joint tightness at 150 % of maximum working/system pressure it is likely to subject to.

Further the contractor shall offer ultrasonic testing for 15% of welded length of each field joint of pipe at site.

j) Backfilling

Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. The water content of the soil shall be as near the optimum moisture content as possible. Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal

pressure does not occur. Backfilling shall be done in layers not exceeding 30cm. Each layer shall be consolidated by watering, ramming, care bring taken to avoid damage to the pipeline. In case of the mild steel pipes/specials, the spiders provided during assembly and welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipeline to aid alignment, these timbers shall be removed before backfilling.

k) Reinstatement of Road/Footpath

Reinstatement of road/footpath shall be done as per the requirements of local authorities and the Employer's requirements after completion of work.

l) Clearing of Site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by the Employer's representative and the construction site left clean to the satisfaction of the Employer's representative.

Applicability

The following clauses specify general mechanical requirements and standards of workmanship for equipment and installation and must be read in conjunction with the particular requirements for Contract. These general specifications' clauses shall apply where appropriate, except where redefined in the particular sections of the technical specifications which shall be applicable.

List of Standards

Titles of various standards referred to in the specifications are indicated below. This list does not necessarily cover all the standards referred to.

BS 5135	Specification for arc welding of carbon manganese steels
BS 5316 Part-2	Specification for acceptance test for centrifugal, mixed flow and axial pumps – Test for performance and efficiency
BS 6072	Method for magnetic particle flow detection
BS 6405	Specification for non-calibrated short link steel chain (Grade 30) for general engineering purposes: Class 1 & 2
BS 6443	Method for penetrate flow detection
ASTM A-36	Specification for Structural Steel
ASTM A-216	Specification for Steel Castings, Carbon suitable for fusion welding for high temperature service
ASTM A-276	Specification or stainless steel and heat resisting steel bars and shapes
ASTM A-351	Specification for castings, Austenitic – Ferric (Duplex) for Pressure containing parts
ASTM A-743	Specification for castings, Iron – Chromium, Iron – Chromium – Nickel and Nickel Base Corrosion Resistant for general Application
ASTM A-744	Specification for castings, Iron Chromium – Nickel, Corrosion – Resistant
IEC – 189 Part 1 & 2	Low frequency cables and wires with PVC insulation and PVC Sheath
AWWA C 501	Cast Iron Sluice Gates
IS 5	Colours for ready mixed paints and enamels
IS 210	Grey Iron Castings
IS 318	Leaded Tin Bronze Ingots and Castings
IS 325	Three Phase Induction Motors
IS 807	Code of Practice for Design, manufacture, erection and testing (Structural Portion) of cranes and hoists
IS 1239	Mild Steel tubes, tubular and other wrought steel fittings
IS 1536	Centrifugally Cast (Spun) iron pressure pipe for water gas and sewage
IS 1537	Vertically cast iron pressure pipes for water, gas and sewage
IS 1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage
IS 1554	PVC insulated (Heavy duty) electric cables
IS 2062	Steel for general structural purposes
IS 2147	Degrees of protection provided by enclosures for low voltage switch gear and control gear
IS 3177	Code of practice of electric overhead traveling cranes and gantry cranes other than steel work cranes
IS 3624	Vacuum and Pressure gauges
IS 3815	Point hooks with shank for general engineering purposes

BS 2910	Methods for radiographic examination of fusion welded circumferential butt joints in steel pipes
BS 3017	Specification for mild steel forged ram shorn hooks
BS 3100	Specification for steel castings for general engineering purposes
BS 3923	Methods for ultrasonic examination of welds
BS 4360	Specification for weldable structural steels
BS 4772	Specification for ductile iron pipes and fittings
BS 4870	Specification for approval testing of welding procedures
BS 4871	Specification for approval the sting of welders working to approved welding procedures
BS 4942	Short chain link for lifting purposes
IS 1710	Specification for Pumps – Vertical Turbine Mixed and Axial Flow, for Clear, Cold Water
IS 5120	Technical requirements of roto dynamic special purpose pumps
IS 5600	Horizontal / vertical non clog type centrifugal pump for sludge handling
IS 6595	Horizontal Centrifugal Pumps for Clear, Cold Water
IS 7090	Guide lines for rapid mixing devices
IS 7208	Guide lines for flocculator devices
IS 10261	Requirements for clarifier equipment for waste water treatment
IS 8413	Requirements for biological treatment and equipment
Part-II	Activated sludge process and its modifications
IS 10037	Requirements for sludge dewatering equipment, sludge
Part-I	Drying beds, sand, gravel and under drains
IS 6280	Specification for Sewage Screens
IS 3938	Electric Wire rope hoists

Further, following codes and standards unless specified herein shall be referred to for pipe lines, pipe works and fittings.

IS 210	Specification for grey iron casting
IS 290	Specification for coal tar black paint
IS 456	Code of practice for plain and reinforced concrete
IS 458	Specification for pre cast concrete pipes (with and without reinforcement)
IS 516	Method of test for strength of concrete
IS 638	Specification for sheet rubber jointing and rubber insertion jointing
IS 783	Code of practice for laying of concrete pipes
IS 816	Code of practice for use of metal arc welding for general construction in mild steel
IS 1367	Technical supply conditions for threaded steel fasteners
IS 1387	General requirements for the supply of metallurgical materials
IS 1500	Method for Brinell hardness test for metallic materials
IS 1536	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS 1537	Specification for vertically cast iron pressure pipes for water, gas and sewage
IS 1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage
IS 1916	Specification for steel cylinder pipes with concrete lining and coating
IS 2078	Method for tensile testing of grey cast iron
IS 3589	Specification for MS Spirally Welded Pipes
IS 3597	Method of tests for concrete pipes

IS 3658	Code of practice for liquid penetrant flow detection
IS 5382	Specification for rubber sealing rings for gas mains, water mains and sewers
IS 5504	Specification for spiral welded pipes
IS 6587	Specification for spun hemp yarn
IS 7322	Specification for specials for steel cylinder reinforced concrete pipes
IS 8329	Specification for DI pipes
IS 9523	Specifications for DI fittings
IS 4984	Specifications for HDPE pipeline
IS 14846	Specifications for valves
IS 783	Code of practice for laying of concrete pipes
IS 3114	Code of practice for laying of cast iron pipes
IS 3764	Excavation work - Code of Safety
IS 4127	Code of practice for laying of glazed stoneware pipes
IS 5822	Code of practice for laying of electrically welded steel pipes for water supply.
IS 6530	Code of practice for laying of asbestos cement pressure pipes.

Materials

All materials incorporated in the works shall be the **most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfection and selected for long life and minimum maintenance.**

Design and Construction

a. The plant design, workmanship and general finish shall be of sound quality in accordance with good engineering practice. Design shall be robust and rated for continuous service, at the specified duties, under the prevailing operational site conditions.

b. The general design of mechanical and electrical plant particularly that of wearing parts, shall be governed by the need for long periods of service without frequent attention but shall afford ready access for any necessary maintenance.

c. Similarly items of Plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same material specification as the originals.

d. No welding, filling or plugging of defective work will be permitted without the written permission of the Engineer. All welding spatter shall be removed.

e. It shall be the responsibility of the contractor to ensure that all the equipment selected is fully compatible, mechanically, electrically and also with respect to instrumentation, control and automation.

f. It shall be the responsibility of the contractor to ensure his equipment interfaces with any existing equipment correctly. Any interfaces must not affect the integrity of the equipment, or invalidate any warranties or guarantees.

g. Each component or assembly shall have been proven in service in a similar application and under conditions no less than those specified therein.

h. The equipment shall be compatible with the civil structure, when installed, with sufficient space for operator access and maintenance procedures.

i. All materials shall be of the best commercial quality and free from any flaws, defects or imperfections.

j. Materials shall be selected to eradicate or reduce corrosion to a minimum.

Tropicalization

Equipment is to be designed for tropical climate suitable for Indian conditions and the city/location where it is to be installed and the following shall apply.

i. Tropical grade materials should be used wherever possible. Some relaxation of these provisions may be permitted where equipment is hermetically sealed.
ii. Iron and steel and in general to be painted or galvanized as appropriate in accordance with the specification. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electro-magnets and the metal parts of relays and mechanisms are to be treated in an approved manner to prevent rusting. Cores etc. which are built up of lamination or can not for any other reasons be anti rust treated, are to have all exposed parts thoroughly cleaned and heavily enameled, lacquered or compounded.
iii. The use of iron and steel is to be avoided in instruments and electrical relays whenever possible. Steel screws, when used, are to be zinc, cadmium or chromium plated or, when plating is not possible owing to tolerance limitations, shall be corrosion resisting steel. Instruments screws, except those forming part of a magnetic circuit, are to be of brass or bronze. Springs are to be of brass, bronze or other non-rusting material. Pivots and other parts for which non-ferrous material is unsuitable are to be of an approved stainless steel.
iv. Fabrics, cork, paper and similar materials, which are not subsequently to be treated by impregnation, are to be adequately treated with an approved fungicide. Sleeving and fabrics treated with linseed oil or linseed oil varnishes are not to be used.

Climate

i. All part and materials used shall in all respects be suitable for the climatic conditions of the city/location where it is to be installed. The following maximum conditions shall be used for all design.

Maximum Ambient Temperature for Design Purpose	:	**50 ^{0}C**
Maximum Relative Humidity	:	95%

In damp situations and wherever exposed to the weather, precaution shall be taken against corrosion of metal work, cable armour conduit and the like.

De-Rating due to the Climatic Conditions

i. All electrical equipment including cables shall be de-rated for continuous operation in an ambient temperature of 50 ^{0}C in accordance with the appropriate regulations unless otherwise specified.
ii. All materials and equipment which are subject to certification by testing authorities etc. shall be certified as being tested at 50 ^{0}C ambient unless other higher temperature specified elsewhere for specific equipment/product.

Packing and Delivery

a. All part and equipment as necessary shall be packed in first quality containers or packing; no second hand timber shall be used. All packing must be suitable for several stages of handling via sea or air freight, inland transport and movement on site.

b. Flanged pipes are to have their open ends protected by adhesive tape or jointing and are then to be covered with a wooden blank flange secured by service bolts.

c. The sleeves and flanges of flexible couplings shall be bundled by wire ties. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 500 kg gross.

d. Precaution is to be taken to protect shafts and journals where they rest on wooden or other supports likely to contain moisture. At such points wrappings impregnated with anti-rust composition or vapour phase inhibitors are to be used of sufficient strength to resist changing and indentation due to movement which is likely to occur in transit. The **form of the protective wrappings and impregnation are to be suitable for a minimum period of twelve months.**

e. Lids and internal cross battens of all **packing cases are to be fixed by screws and not nails.**

Hoop metal bindings of cases are to be sealed where ends meet and if not of rust less material are to be painted. Contents of cases are to be bolted securely or fastened in position with struts or cross battens and not with wood chocks, unless they are fastened firmly in place. All struts or cross battens are preferably to be supported by cleats fixed to the case above and below to form ledges of which the batten may rest. Cases are to be up-ended after packing to prove that there is no movement of contents.

Where parts are required to be bolted to the sides of the case, large washers are to be used to distribute the pressure and the timber is to be strengthened by means of a pad.

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Where parts are required to be bolted to the sides of the case, large washers are to be used to distribute the pressure and the timber is to be strengthened by means of a pad.

All stencil marks on the outside of the casings are to be either of a water proof material or protected by Shellac or varnish to prevent obliteration in transit.

f. Wood wool is to be avoided as far as possible. Waterproof paper and felt linings are to overlap at seams at least 12mm and the seams secured together in an approved manner, but the enclosure is to be provided with screened openings to obtain ventilation.

g. Where applicable, indoor items such as electric motors, winch and control gear, instruments and panels, machines components etc. are to be ‘cocooned’ or covered in polythene sheeting, selected at the joints and the enclosures provided internally with an approved desiccators.

h. Bright metal parts are to be covered before shipment with an approved protective compound or coating and protected adequately during transport to site. After erection these parts are to be cleaned by the Contractor.

i. Each crate or package is to contain a packing list in a waterproof envelope and copies in duplicate are to be forward to the Engineer; prior to dispatch. All items of material are to be clearly marked for ready identification against the packing list.

All cases, packages, etc. are to be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and to indicate the correct positions for slings and are to bear an indelible identification mark relating them to the appropriate shipping documents.

j. Structural steel work, pipes, valves, encased fittings and metal work shall be similarly marked. In addition, one in every ten repeated articles shall bear the dispatch marks in suitable paint or other approved medium. When in the opinion of the Engineer, the dispatch marks can not be applied satisfactorily to any item, they shall be stamped on a petal label attached to the item they shall be

stamped on a metal label attached to the item or part by means of a piece of wire passing through holes at either end of the label and secured so that it lies flat with the item.

k. The Engineer may require inspecting and approving the packing before the items are dispatched but the **contractor is to be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not relieve the Contractor for any loss or damage due to faulty packing.**

Finish

Workmanship and general finish shall be of first-class commercial quality and in accordance with best practice. All covers, flanges and joints shall be properly faced, bored, fitted, fixed, hollowed, mounted or chamfered as the case may be, according to the best approved practice and all working parts of the plant and other apparatus, shall similarly be well and accurately fitted, finished, fixed and adjusted.

Wrought Steels

Where not otherwise specified wrought steel shall be selected from the appropriate grade of IS: 1570 and be free from blemishes, short or hammer marks.

The Contractor shall submit for the approval of the Engineer-in-charge, the grade number selected for each component.

Castings

All casting shall have a homogenous structure and be free from blow holes, flaws and cracks. Any casting having a thickness in parts in excess of 3 mm to that which it is purported to be shall be rejected. No repairs or patchwork to castings shall be allowed other than that approved by the Engineer-in-charge.

Castings subject to hydraulic pressure shall be tested to 1.5 times the maximum working pressure. Certified copies of Test Reports shall be forwarded to the Engineer as soon as the test is completed.

Steel Castings

Where not otherwise specified, steel castings shall be selected from the appropriate grade of BS 3100.

Grey Iron Castings

All grey iron castings supplied shall be to the appropriate grade of IS: 210. The Contractor shall replace any casting which the Engineer considers is not of first class appearance or is not in any way the best which can be produced, although such a casting may have passed the necessary hydraulic or other tests. No plugging, filling, welding or “burning on” will be acceptable.

Spheroidal Graphite Iron Castings

All spheroidal graphite or modular graphite iron shall be to the appropriate grade of BS 2789.

Bronze
Where not otherwise specified, the bronze used shall be made of a strong and durable zinc free mixture to IS: 318.

Aluminum and Aluminum Alloys
Bars and extruded sections shall be to designation EN 8 or BS 1474. Aluminum and aluminum alloys shall not be utilized unless alternative materials are considered unacceptable. The use of aluminum requires the approval of the Engineer in all cases.

Aluminum and Aluminum alloy Castings

Castings shall be manufactured from LM5 to BS 1490 and subjected to a chill cast to increase tensile strength. Aluminum and aluminum alloys shall not be utilized unless no other materials is considered suitable. Immersed structures or structures that are periodically immersed shall not be constructed from aluminum or aluminum alloys.

Painting and Metal Protection

All bright metal parts shall be covered before shipment with an approved protective compound and adequately protected during shipment to site. **After erection these parts are to be cleaned.**

All exposed metal parts of the equipment including piping, structures, etc. wherever applicable, after installation unless otherwise surface protected shall be first painted with at least one coat of suitable Zinc rich epoxy primer which matches the shop primer paint used, after thoroughly cleaning all such parts of all dirt, rust, scales, greases, oils and other foreign materials by wire brushing, scraping or sand blasting and the same being inspected and approved by the Engineer for painting. After wards, the above parts shall be finished with two coats of epoxy/coal tar epoxy coating/paint. The quality of the finish paint shall be as per the standards of ISI or equivalent and to be of the colour as approved by the Engineer. The paint shall be suitable for use in industrial corrosive works atmosphere.

All bright metal parts shall be covered before shipment and transportation with approved protective compound and protected adequately during shipment and transportation to the site. After erection, these parts are to be cleaned.

All pipe services wherever applicable are to be painted in accordance with the Owner's standard colour code scheme, by the Contractor.

MS/GI Hand Rails shall be painted with synthetic enamel paint or as specified in Scope of Work/ process description/Process Design Criteria and detailed Specifications and of shade approved by engineer-in charge.

Chromium Plating

All chromium plating shall comply with IS: 1986.

Galvanizing

Where steel or wrought iron is to be galvanized, it shall be carried out by the hot-dip process and shall conform in all respects with IS: 2629.

Attention shall be paid to the details of members in accordance with BS: 4479. Adequate provision for filling, venting and draining shall be made for assemblies fabricated from hollow section. Vent holes shall be suitably plugged after galvanizing.

All surface defects in the steel including cracks, surface lamination, laps and folds shall be removed in accordance with IS: 6159. All drilling, cutting, welding, forming and final fabrications of unit members and assemblies shall be complete before the structures are galvanized. The surface of the steel work to be galvanized shall be free from welding slag, paint, oil, grease, and similar contaminants. The articles shall be pickled in dilute sulfuric or hydrochloric acid, followed by rinsing in water and pickling in phosphoric acid. They shall be thoroughly washed, stoved and dipped in molten zinc and brushed, so that the whole of the metal shall be less than 610 grams per square meter of surface galvanized, except in the case of tubes to BS 1387 when it shall be 460 grams per square meter.

On removal from the galvanizing bath the resultant coating shall be continuous, adherent, as smooth and evenly distributed as possible, and free from gross imperfections such as bare spots, lumps, blisters and inclusions of flux ash or dross etc. and free from any defect that is detrimental to the stated end use of the coated article. Edges shall be clean and surfaces bright.

Bolts nuts and washers shall be hot dip galvanized and subsequently centrifuged in accordance with IS: 2669. Nuts shall be tapped up to 0.4mm oversize before galvanizing and the threads oiled to permit the nuts to be finger turned on the bolt for the full depth of nuts.

During off-loading and erection, the use of nylon slings shall be used. Galvanized work which is to be stored in works or on site shall be stacked so as to provide adequate ventilation to all surfaces to avoid wet storage staining.

Small areas of the galvanized coat damaged in any way shall be restored by following.

i. Cleaning the area of any weld slag and thoroughly wire brushing to give a clean surface.
ii. The application of two coats of zinc-rich paint (not less than 90% zinc dry film), or the application of a low melting point zinc alloy repair rod or power to the damaged area, which is heated at 300 ^{0}C.

Where surfaces of galvanized steel work are to be in contact with aggressive solutions and/or atmospheres the galvanizing shall receive further protection by painting.

Fasteners

Bolts, nuts and studs and fasteners with nominal diameters up to and including 39 mm required to be made in carbon steel shall conform to BS 6104 and threaded in accordance with IS: 1363 and 1367. Bright steel washers 3.0mm in thickness shall conform to BS 4320 and shall be provided beneath bolt head and nut.

The above items required to be supplied in stainless steel shall conform to IS: 1570. These items together with holding down bolts and anchor plates required to be supplied in high tensile steel shall conform to BS 970 Ref. Symbol T.

Drilled anchor fixings fasteners for use on concrete structures shall be of an approved type by the Engineer's Representative. The Positions of all drilled anchors shall be approved by the Engineer's representative and a Contractor proposing to use such fixings shall be deemed to have undertaken to supply, mark off, drill and fit. All exposed bolt heads and nuts shall be hexagonal and the length of all bolts shall be such, that when fitted and tightened down with a nut and washer, the threaded portion shall fill the nut and not protrude from the face thereof by more than a half diameter of the bolt. Rivets shall conform to BS 641 and tested in accordance with BS 1109.

Forgings

Carbon steel forgings shall be manufactured heat treated forgings and tested in accordance with BS 29.

Foundation and Settings of Machinery

The Contractor shall arrange for the provision of all foundation and plinths required for the plant and shall be responsible and setting for ensuring that all foundations and plinths are constructed and boxed out for Machinery holding down bolts in accordance with the approved drawings.

The Contractor shall provide all necessary templates for suspension of the holding down bolts during grouting of same.

The Contractor shall visit the site during the course of construction and check the Civil Works to ensure that the foundation and/or plinths are at correct required location and height for the acceptance of the

machinery. When the foundations and/or plinths have been complete and are in a satisfactory condition, the machinery shall be installed as directed by the Engineer's representative.

The machinery shall be mounted on flat steel packing of a thickness selected to take up variations in the level of the correct foundations. The packing shall be bedded by chipping or grinding of the concrete surface.

Only one packing of selected thickness shall be used at each location, which shall be adjacent to each holding down bolt. The number of shims shall not exceed two at each location and the thickness of each shim shall not exceed 3mm.

The machinery shall be alighted, leveled and pulled down by the nuts of the holding down bolts with a spanner of normal length, and no grout shall be applied until the machinery has been run and approved by the Engineer for stability and vibration. The Civil Works Team shall then carry out the grouting and building in of the machinery. However, the Contractor shall take responsibility for the satisfactory nature of this work, and shall have a representative present.

Built In Items

The Contractor shall include in the relevant Schedule of the Specifications, details of all the items of equipment to be "Built in" by the Civil Works Team, together items with details of the period in which these items could be delivered to site.

The Contractor shall provide to the Civil Works Team full details of the box outs and plant fixing and foundation requirements for incorporating in the Civil Work. The Contractor shall liaise closely with the Civil Work and shall obtain from him a program of the civil works, clearly showing the dates when box-out and plant foundation details will be required. The Contractor will be responsible for co-coordinating and program his work schedule with the Civil Work so as to ensure an optimum arrangement with the minimum of disturbance to the progress of the Works as a whole. The Contractor shall deliver all items of equipment that are required to be built in the civil works, as required by the construction program and shall arrange for a representative from the equipment supplier to be in attendance during the progress of such works. The Civil Works team shall grout up and make good when instructed by the Engineer's representative.

Location and Alignment

Where individual items of equipment and mechanically located and coupled, such as alignment motors, gear boxes and similar items depended upon correct alignment for satisfactory operation, each shall be mounted on a common bed plate and when alighted shall be located by means of dowels to ensure that correct re-alignment can be easily achieved when re-assembling the items after removal for overhauls.

Coupling

Flexible couplings shall be couplings rated at not less than the stalling torque load of the motor. Couplings liable to impregnation by oil shall be of the all metal flexible type.

General Service coupling shall be of the flexible multi-pin and resilient bush type, having not less than six bushes and each bush shall have an inner sleeve to allow rotation on the pin (bushes shall not be in direct contact with the pin). All pins shall have shoulders to allow positive location and securing to the half coupling face.

Flexible couplings shall be supplied in matching balanced sets machined, balanced and marked before leaving manufacturer's works. The couplings shall be a tight fit on the shafts and secured with hand fitted keys and fully checked for alignment shall be a tight fit on the shafts and secured the hand fitted keys and

fully checked for alignment. All necessary equipment for checking alignment shall be supplied by the Contractor.

Where flexible coupling are used, the Contractor shall fully describe the arrangements proposed for ensuring that the desired freedom of relative movement between the shafts is obtained when transmitting a torques corresponding to the continuous maximum rating of the motor.

Solidly bolted couplings shall be subject to accurate alignment and the Contractor's proposed alignment procedure shall be subject to the approval of the Engineer. In particular, the alignment procedures which involve rotating one half coupling only will not be accepted.

Overload release couplings shall not rely on shear pins. Release torque shall be adjustable over a wide range and preferably without the need to change components. The coupling shall be capable of angular alignment of 1 degree maximum and 1mm displacement of shafts.

Hydraulic couplings shall be oil filled with thermal overload protection device. The coupling shall be fully rated to transmit the motor full load power without exceeding normal working temperature and due regard shall be taken to ambient temperatures. An enclosure around the coupling shall be provided to prevent oil spray in the event of operation of the thermal overload device.

Final alignment of all types of coupling shall be checked by the Contractor in the presence of the Engineer's Representative.

Bearings and Lubricators

The size of bearing shall be not less than that calculated for bearings and a minimum L10 basic rating life in accordance with BS 5512 Lubricators Part 1, taking into account all considerations of reliability materials of manufacture and operating conditions. All bearings shall be rated and sized to ensure satisfactory running without vibration under all conditions of operation for a minimum life of 50,000 hours running.

They shall be efficiently lubricated and adequately protected from ingress of moisture, dust and sand and the particular climatic condition prevalent at the site. All bearings shall be to ISO standard SI unit dimensions where practicable.

All ball or roller bearings, except those supplied and "sealed for life" shall be arranged for grease gun lubrication and a suitable high pressure grease gun shall be supplied.

Adequate "Stauffer" screw top pressure grease lubricator with 'tell tale' stems or 'Tat" grease nipples shall be provided for all moving parts. The position of all greasing and oiling points shall be arranged so as to be readily accessible for routine servicing. Wherever necessary, suitable access platform shall be provided.

The type of lubricant and intervals of lubrication, which shall be kept to a minimum (not less than nine days), for each individual item of plant shall be entered on a working schedule, which shall form part of the Operation and Maintenance instructions.

A list of recommended Lubricants and their equivalents Bearings shall be entered in the Operation and Maintenance instructions.

Gear boxes

The gear boxes shall be totally enclosed dust, water and hose proof. Suitable lifting lugs shall be provided. They shall be robustly constructed and arduous duty.

The gear case shall be manufactured from grey cast iron to IS: 210 and of a grade to ensure high strength and wear resistance. Inspection covers shall be provided together with protected oil level indication, breather with oil mist preventer and drain plugs.

The gear boxes shall be designed for operation at the ambient temperatures specified without the assistance of a cooling fan.

The **mechanical service factor shall be not less than 1.5** when applied to the rated motor power or higher as recommended by equipment manufacturer.

The gears shall be manufactured from steel to BS 970 of grade selected by the Contractor and entered in the Schedule of Particulars. The teeth shall be profile ground and lapped to a high standard of accuracy and finish.

Rolling bearings shall be adequately rated to ensure a running life of not less than 50,000 hours L10 life.

The input and output shafts shall have oil seals fitted to prevent the ingress of lubricant when the gearbox is mounted in the required orientation. For example, inclined when applied to screw pump installations.

The seals shall also prevent the ingress of dust, sand and moisture.

Lubrication of the gears shall be by a splash or forced system.

An anti-run back device shall be supplied and fitted to all gearboxes involved in screw pump installation.

Each gear unit shall be subjected to a full load test at the inclinations specified for duration of 3.00 hour during which time temperature, vibration and noise levels together with oil tightness shall be recorded in the presence of the Engineer's representative.

After satisfactory completion of the tests, each unit shall be drained of lubricant. All internal surfaces shall then be coated with suitable preservative.

A metal label shall be securely wired to the gear case to clearly state that the gear case requires to be coated with a suitable preservative.

The gear box shall be securely wired to the gear case to clearly state that the gear case requires to be filled with lubricant, the type and grade of which shall be clearly identifiable.

A metal label shall be securely wired to the gear case to clearly state that the gear case requires to be filled with lubricant, the type and grade of which shall be clearly identifiable.

Steelwork General

The Contractor shall provide and fix all the steel work, including stairways, ladders, hand railing, checkered plate and open mesh flooring frames and curbing as detailed in the specification and/or as shown on the contract drawings or as directed by Engineer.

All steel work shall be constructed in mild steel and shall be galvanized after manufacture or shall be provided with finish as specified in the specifications of specific equipment/work.

For all pre-fabricated metal work, including multiple duct covers, external ladders, open mesh flooring, checkered plating, hand railing, staircase, structural steel work and the like, the Contractor shall submit fabrication drawings for the approval of the Engineer prior to the manufacture of any of these items.

Hand Railing and Safety Chains

Hand Railing

Hand railing shall be of MS ERW Medium Class of circular hollow section and shall comply with the relevant requirements of BS 1387, BS 6323 Part I or BS 4360. Mild steel toe boards shall be provided, 100mm high by 3mm thick positioned above the platform level and fixed securely to the standards. All items shall be painted with epoxy paint & epoxy primer.

Standards shall not be less than 38mm external diameter and rails shall not be less than 32mm external diameter.

Horizontal handrails shall be 1000mm high with an intermediate rail at mid height. Handrail height shall be measured vertically from finished floor level to the hand rail centerline.

Handling and fixings shall be designed to withstand a horizontal force of 740 N/m run without permanent distortion or failure of components. When a horizontal force of 360 N/m is applied at handrail level the deflection at any point on the handrail shall not exceed 1/125 of the distance between the center lines of adjacent standards or 10mm whichever is the least.

All mounting flanges shall be of substantial construction, with horizontal flanges drilled for not less than three bolts with two bolts on a line parallel to and on the walkway side of the line of the hand railing and vertical flanges drilled for less than two bolts and line through the bolts being vertical. Fittings shall be screwed or secured with grub screws. The standards shall be set at not more than 1.5 m. centers. When provided in sections, hand railing shall be joined together with purpose made fittings secured by screws or grub screws.

All ladders, stairway or other openings shall be guarded on three sides by hand railing conforming to the requirements stated above.

The Contractor shall ensure that unless specified hereinafter to the contrary, all hand railing shall be of uniform appearance and manufacture.

Safety Chain

Mild steel safety chain shall be 8mm nominal size grade (M 4) non calibrated chain Type 1, complying with BS 4942 Part 2. After manufacture, mild steel safety chains shall be hot dipped galvanized in accordance with BS 729.

Stainless steel safety chains shall be manufactured from grade 316S31 steel complying with ISO 570 Part 1. Chain links shall be welded and have an internal length not exceeding 45 mm and an internal width of between 12mm and 18mm. The fins caused by welding shall be removed and the weld shall be smoothly finished all round. When tested in accordance with clause 7.3 of BS 4972 Part 2, each chain shall with stand a breaking force of 30kN and a proof force of 15kN.

Open Mesh and Chequer Plate Flooring

Open mesh flooring and gratings shall generally comply with BS 4592 except where otherwise specified hereinafter. Such flooring and gratings shall be of rectangular mesh and non–slip and shall be mild steel galvanized.

Flooring shall be provided to span between the supporting members as shown on the Contract Drawings.

Where necessary intermediate support members shall be provided and fixed.

Galvanized mild steel toe plates 100 mm high and not less than 3mm thick shall be provided and fixed at all cut-outs except where otherwise shown on the approved drawings.

Both the load bearing and transverse bars in rectangular flooring panels shall be obtained systemically around the centre lines of the panels in both directions, so that when the panels are fixed in extensive areas or in long runs, the bars of all panels are in line.

Chequer plate flooring shall be galvanized and of the non-slip type, not less than 10mm thick measured excluding the raised pattern. The flooring shall be secured to its frame by stainless steel countersunk set screws.

All flooring shall be designed to carry a loading of 750 kg/sq. meter and the deflection shall not exceed 1/200 of the span or 10mm whichever is the least.

All flooring shall be removable and set flush in mild steel galvanized frames. All frames shall be provided with lugs for building in.

Flooring shall be provided in sizes suitable for lifting and removal by one man and with the appropriate cutouts to permits its removal without disturbing or dismantling spindles, supporting brackets, cables or pipe work. Flooring spanning wide openings shall be supported on removable bearers and fixings to provide the required rigidity and these shall be supplied and fitted by the Contractor. These members shall be removable to afford clear access to the openings which includes ducts.

Lifting keys shall be supplied for each location and the type of key shall be such that inadvertent release is avoided.

Stairways

Stairways shall be detailed, fabricated and erected to the dimensions shown on the drawings and in accordance with BS : 449 Part 2 to carry a load of 750 kg/sq. meter. Treads shall be rectangular open mesh fixed to the stringers, not directly to concrete. Sloping hand railing shall be as specified for horizontal hand railing but with the top rail 850mm vertically above the line of pitch and standards vertical and spaced at not more than 1500mm., measured parallel to the line of pitch.

Staircases shall be constructed to the size and position shown on the drawings or as instructed by the Engineer. They shall be steel galvanized at works after manufacture and shall comprise stringers supporting the open mesh stair treads and shall be supplied complete with handrails and stanchions conforming to the above except the height which shall be 900mm above the pitch line.

Ladders

Ladders shall conform to BS 4211 except where the specified here after. They shall be in mild steel galvanized as specified in. The stringers shall be flat section not less than 65mm x 10mm spaced 380mm apart and shall be flanged and drilled for wall fixing at both ends. The stringers shall be radiuses over the top where they shall be not less than 600mm apart. Ladders over 3.0 m long shall have additional intermediate stays at not more than 2.5 m centers.

Rungs shall be 20mm diameter round bar at 250 mm c-c distance shouldered at each end and securely riveted into countersunk holes. Rungs shall be not less than 225mm from the wall.

All ladders shall have safety cages which shall be constructed of three flat vertical strips supported by flat hoops, with a diameter of 750mm. The hoops shall be at approximately 70mm centers and the first hoop shall be 2400mm. above ground or lower platform level.

Where the rise exceeds 6000mm, an intermediate landing shall be provided.

Multiple Duct Covers and Frames
Multiple duct covers and frames shall be of cast iron, water proof, non-rocking and recessed for filling with concrete or similar material.

They shall be of the type incorporating integral, removable, intermediate beams to given the required clear pit opening as shown on the approved drawings.

A heavy grease seal is to be formed between the cover and frame to prevent ingress of grit.

General Requirements for Pipe work
The Contractor shall supply, deliver and erect all pipe work and fittings within the structures and externally to the limits indicated on the approved drawings and in accordance with each section of specification.

Pipe work and fittings shall be suitable for a safe working pressure equivalent to the maximum working pressure of the system. The safe working pressure of the pumping mains shall be the closed valve head of the pump plus the maximum suction static head. The maximum surge pressure shall be limited to 125% of the maximum working pressure. All pipe work and fittings shall be of adequate strength to accommodate the maximum surge pressure of the system.

The minimum pressure rating of pipe work and fittings shall be 10 Bar or higher as per process requirement.

There shall be a sufficient number of mechanical joints to enable mechanical plant and valves to be disconnected from built–in pipe work. Such joints shall be tied and shall not be allowed to sustain the weight of any pipe work.

All pipe work and fittings shall be sized for the required capacity at a velocity limits depending on the nature of the fluid or substance to be conveyed.

All pipe work shall be adequately supported by purpose made fixings. Support shall not be provided by plant or equipment.

The position of any thrust blocks required shall be indicated on the Contractor's details drawing together with the position of any sleeping required through partition walls in buildings. Puddle flanges shall be provided for building at locations in which pipes 80mm diameter and above pass through structural concrete below ground level.

Where pipe work is connected to plant and equipment readily demountable fittings in the form of unions or flanged adapters shall be provided. The flanged adapter on the delivery pipe of pumps shall be located upstream of the reflux valve where appropriate.

Flexible joints shall be provided in all pipe work subjected to linear constraint.

All jointing work including the provision of suitable full face gasket not less than 5mm in thickness and galvanized fastenings or fastening as specified shall be included.

Pump suction bell mouths shall be standard castings in either cast iron or ductile iron.

Unless otherwise specified, the pieces shall have a radial branch to enable a more streamlined flow from branch to body. Due allowance shall be made for reinforcement in the vicinity of the branch.

Prior to dispatch, each item of pipe work or associated fitting shall be clearly identified in paint with the plant item number indicated on the Contractor's arrangement drawing.

Puddle flanges shall be provided on all pipes where they pass through pumping station walls/water retaining structure walls. Each puddle flange shall be continuously welded to the pipe on both sides of the flange.

Pipe jointing surfaces and components shall be kept clean and free from extraneous matter until the joints have been made or assembled. Care shall be taken to ensure that there is no ingress of grout of other extraneous material into the joint annulus after the joint has been made.

The dimensions of gaskets shall comply with BS 4865 Part I. Gaskets shall be manufactured from material complying with BS 2494 for Type 1 rings.

Pump suction and delivery manifolds shall be provided with a drain valve where natural drainage does not occur.

Hydraulic testing shall not be carried out until all fabrication has been completed. When the pressure applied and sustained without further pumping shall be twice the working pressure.

The Contractor shall be responsible for cleaning the internal surface of all pipes prior to erection particularly the removal of weld deposits. Initial capping of the ends for protection during transport and storage shall not be removed until erection takes place.

Grey Iron Pipe work and Fittings
Grey Iron flanged pipe work shall conform to BS 4622 – not less than Class 3 with flanges to BS 4504 Part 1 – table 16.

Spheroidal Graphite Cast Iron Pipe work and Fittings

All spheroidal graphite or modular graphite cast iron pipe work and fittings shall be to the appropriate grade of BS 4772.

Carbon Steel Pipe Work

Carbon Steel Pipe work for pressure purposes shall be to BS 3601 and assemblies shall be manufactured from pipe to this specification. The type of pipe shall be hot finished seamless steel. The wall thickness shall be not less than that required in BS 534 Table – 1.

ABS Pipe Work
ABS Pipe work shall be provided and installed for special purposes where hereinafter specified. The pipe work shall conform to BS 5391 and the fittings to BS 5392.

Fabrication of Carbon Steel Pipe Work and Fittings
The Contractor shall fabricate the pipeline by butt-welding without utilizing a backing ring in accordance with BS 2971 Class II metal arc welding of carbon steel pipe work. Branches shall be formed in accordance with BS 2971 (Class I or Class II, depending on operating conditions) and shall be welded before so that at any point along the bend, ovality will not reduce the bore by more than 21%. Radii of hot bends for all pipes shall not be less than five times the outside diameter. Gusseted "Cut and Shut" and wrinkle. All pipe flanges shall be of the wrought steel slip on type conforming to BS 4504 PN 16, welded on in accordance with BS 2971 (Class I or Class II, depending on operating conditions). No flanged joints shall be located within a backfilled trench. Flexible joints shall be bolted gland or Victaulic coupling as necessary.

Welder Qualification
Before welding work commences on pipe work, the Contractor shall satisfy the Engineer's representative that the welders have previously carried out similar welding work within recent months. When instructed

by the Engineer's representative, the Contractor shall arrange for the welder to produce test welds in accordance with the provisions of BS 2971.

Pipe Work Installation
All pipe work, pipe fittings, jointing materials etc. shall be of the best quality free from defects an obtained from a supplier approved by the Engineer. The installation of the pipe work shall be carried out using skilled personnel and pipe work shall be installed according to the drawing approved by the Engineer. Where valves are incorporated in pipe work, the valves shall be provided with their own supports, such that no excess loading is exerted on pipe work. All pipe work materials shall have no excess loading is exerted on pipe work. All pipe work materials shall be off-loaded, stored on site and handled thereafter in such a manner that they are adequately protected for damage or deterioration.

Underground Pipes

Unless otherwise state all underground pipes shall be buried in trenches which have been excavated in accordance with the relevant section of the specification.

Examining Pipes

Before being used, each pipe casting or fitting shall be properly examined and should appear defective in any way, it shall be set apart and not used until it has been examined and passed by the Engineer. All metal pipes which shall be buried in the ground shall, prior to their installation, be slung and sounded in an approved manner. Any pipe found to be faulty by this method, shall be set aside for examination by the Engineer.

Cutting Pipe Work
All pipe work shall be cut with proper pipe cutting tools. The use of hammer and chisel for this purpose shall not be permitted. Great care shall be exercised when cutting concrete/bitumen lined spun iron and ductile iron pipes, to ensure that there is no damage to the lining. Should any damage to the lining take place which is to an extent which the Engineer deems to be undesirable, then the pipe shall be rejected. The Contractor shall then prepare another pipe for incorporation into the works. All pipes which have been cut shall have the edges dressed and deburred.

Labels
The Contractor shall arrange for the supply and fitting of engraved identification labels to all valves and items/equipment of plant. The reference numbers of all valves shall be as indicated on the schematic diagram to be supplied under the Contract.

All warning labels shall comply with BS 5378 parts 1, 2 and 3 and screw fixed rigid construction.

Designation labels shall be of 5mm trefoil with black lettering on white background. Embossed materials and techniques shall not be accepted.

The Contractor shall provide 2 nos. enameled iron plates worked "Men Working of Plant". The plates shall be 200mm x 75mm with red lettering on a white background.
N. B.: All identification and warning labels shall be in ("Hindi Language") and English.

Guards

Adequate guards shall be supplied and installed throughout the installation to cover drive mechanisms. All rotating and reciprocating parts, drive belts, etc. shall be securely shrouded to the satisfaction of the Engineer to ensure the complete safety for both maintenance and operating personnel. However, whilst all such guards shall be of adequate and substantial construction, they shall also be readily removable for gaining access to the plant, with out the need for first removing or displacing any major item of plant. The guards shall be of the open mesh type except where retention of fluid spray is required.

Suppression of Noise

All plant equipment offered shall be quiet in operation. The noise level within the building shall not be more than 85 dB (+5 percent on this over the audible frequency spectrum measured at mid-band), "A" scale when measured along a contour 3 meters from any single item of plant during starting, running and stopping. The noise level outside the building shall not be more than 60 dB (+5 % on this over the audible frequency spectrum measured at mid-band), "A" scales when measured along a contour 3 meters from the external wall. Noise test measurement shall be made on completion of the installation of the plant at Site to verify that it complies with this Clause. Plant which fails to comply with the noise level limits when tested which render it liable for rejection unless it is satisfactorily modified at the Contractors expense by the programmed commissioning date.

Trolley and Chain Pulley Block

a. The chain pulley block shall be operated on the lower flange of the bridge girder.
b. 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.
c. The hand chains 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.
d. 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.
e. The trolley track wheel 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.
f. The traveling trolley frame shall be made of rolled steel conforming to IS: 2062. The side plate 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.
g. Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.
h. The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. They shall be of single hook type provided with a standard depressed type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swiveling shall be provided. Hook shall be as per BS 2903/IS: 3815.
i. The brake for the lifting gear shall be automatic and always in action. It shall be of screw and friction disc type self–actuating load pressure brake. Brakes shall offer no resistance during hoisting.
j. If the weight of offered pump set/equipment is more than the craned capacity specified, the contractor shall offer the crane capacity 1.5 times higher than the weight of the pump set/ equipment or as per latest IS.

Pipes and Fittings

a. The cast iron pipes shall generally conform to class B IS: 1537/IS: 1536/IS: 7181 and pipe fittings shall conform to IS: 1538. Ductile Iron pipes shall conform to IS 8329/BS: 4772.
b. The material for cast iron pipes and fittings shall be of grey cast iron conforming to IS: 210, Gr. FG 200.
c. The pipes shall be of uniform bore and straight in axis. Length of the straight double flanged pipes shall be within a tolerance as specified in IS standard.
d. The flanges of the straight pipes shall be square to the axis of the pipe. The faces of the flanges shall be parallel. The bolt holes in one flange shall be located in line with those in order.

e. The faces of the flanges of the fittings shall be square to the directional axes. The holes shall be located symmetrically off the centerline. The intersecting axes of the tees shall be perpendicular to each other.
f. The bolt holes on flanged pipes and fittings shall be drilled with the help of drilling jig. The blank flanges are to be machined and drilled.
g. The dismantling joints shall be of cast iron with EPDM seal ring.

Ventilation Systems
These specifications are common to all dry well/wet well effluent, sewage and water pumping stations and treatment plants. The scope of ventilation system includes following.

a. Supply Air Fans
b. Exhaust Fans
c. Associated Ducting

Wherever the drawings provided for ventilation system, indicate proposed ventilation fans and the routing of ducting. It is the responsibility of the contractor to study and analyse the adequacy of the system and suggest any improvement at the same time taking into consideration all the requirements of the public authorities including safety orders and Fire Protection Rules & Regulations and IS Codes. The necessary permits shall be obtained by the contractor and all payments towards license inspections etc. paid before starting the work.

Supply Air Fans
Air fans shall be of centrifugal type and fan housing shall be hot-rolled steel of thickness 3/8". End flanged shall be fixed to the casing by continuously welding over the entire circumference. The flanges shall have bolt holes for bolting to inlet bell, companion flanges or ducts as the case may be. Housing shall be continuously welded and shall be expanded by suitable mechanical means to insure concentricity. Motor support shall not be less than 3/9" thick steel plate. Support ring shall be continuously welded to the support plate.

Fan rotor and blades shall be made from cast aluminum with suitable corrosion resistant coating. Belt driven fans shall have multi V belts on pulleys with suitable guards. V belts shall be 150% of rated HP duty.

The fan rotor shall be whirl-tested to 125% or operating speed and shall be statically and dynamically balanced on fan motor shaper to maximum tolerance in one (1) mil double amplitude at design operating speed.

The fans shall have inlet screen at inlet bell cone and carbon steel bolts for existing discharges cone with flanges on both ends attachment to fan and to discharge ducting.

Fan motor supports shall be of adequate strength, constructed from 1/4" carbon steel angles. All the external fasteners shall be stainless steel.

Motors
Motors selected for the fan shall be of adequate rating with a safety factor of 1.5 or greater. If the fans are belt-driven the motor shall be mounted on slide rails for belt tension and adjustment. The complete assembly shall be mounted on Neoprene Vibration Isolators. The motor shall conform to the relevant latest Indian Standards of British Standards. It shall have permanently lubricated ball bearings. The motor shall be suitable for 415 V, 3 Phase 50 Hz supply.

The bearing life shall not be less than 20,000 hours at design conditions and motor shall be of class 'F' insulation to allow for operation up to 95 ^{0}C rise over the ambient temperature of 45 ^{0}C. External copper grease leads for lubrication of motor bearings shall be provided by the manufacturer.

Fan motor shall be standard totally enclosed fan cooled (TEFC) foot mounted squirrel cage induction motor with single speed, single winding, continuous duty variable torques.

A conduit box shall be mounted on the exterior of fan casing and lead wires from the motor conduit box shall be protected from the air stream by being encased in a tight metal conduit pipe.

The belt drives shall have stainless steel wire cage guards.

Supply of air fans in dry well shall have air flow switches and pressure switches fitted in the ducting. The selection of these switches is left to the contractor to suit the fan units being supplied.

Exhaust Fans
Exhaust fans shall be of direct drive, impeller propeller type, having maximum speed of 1450 rpm.

All the exposed parts shall be of aluminum, with transparent anodic, anti-salt spray coating. All external fasteners shall be of stainless steel. Hood shall be hinged for accessibility and servicing. Fans shall be complete with aluminum bird screens, Plastic or light weight aluminum back draft compels and electrical disconnecting means beneath the hood and protective grid guard below fan motor.

Motors shall be of relevant Indian Standards or British standards and shall have permanently lubricated ball bearings. The rating shall be adequate with service factor of 1.50 based on rated horsepower. All motor shall be TEFC and be suitable for continuous operation without exceeding a temperature rise of 50 ^{0}C over ambient.

The motor shall be of constant speed and squirrel cage type, operating on 415 V, 3 phase, 50 Hz supply. Roof mounted motors shall have electrical disconnects.

Contractor shall submit all catalogues showing the sizing and rating of fans with the size of openings to be provided for approval before proceeding with the work.

Dampers
All dampers shall be of louver type, robust construction, and tightly fitted suitable for the location and service required.

Dampers shall have suitable links, levers and quadrants as required for the proper operations, control or setting in any desired position. Dampers and these operating devices shall be made robust, easily operable and accessible through access doors in the ducts. Every damper shall have an indicating device clearly showing the damper position at all items.

Dampers shall be placed in ducts and every branch supply or return air duct connection whether or not indicated on the drawings for the proper volume control and balancing the system.

Grilles and Diffusers
All grilles shall have vertical and horizontal adjustable bars and controlled from the front of the grill.

Installation
The duct fabrication and installation shall generally conform to IS: 655 latest. It is the responsibility of the Contractor to provide and neatly erect all the sheet metal work as shown on the drawings or as required at site to the satisfaction of the Engineer.

All necessary allowances and provisions shall be made by the contractor for beams, pipes or other obstructions in the building, whether or not the same are shown on the drawings. All necessary modifications as required shall be carried out by the Contractor, however maintaining the same area.

All co-ordination with other agencies/contractor working simultaneously at the site to avoid repetition of work shall be the responsibility of the Contractor.

The ducting shall never be hung from the ceiling and only support of beams and columns shall be taken. The ducts shall be rigid and adequately supported and braced with beams or columns. All joints shall be made tight and all interior surfaces smooth bends shall be made with radius not less than one half the width of the duct. All the sheet metal connections, partitions and required to confine the flow of air and through the filters and fans shall be constructed from No. 18 galvanized iron thoroughly stiffened with 25mm x 25mm angle iron braces and fitted all necessary doors, to give access to all parts of the equipment. Doors shall be set conveniently where required. At the connection of ducting and inlet/outlet of fans, a double-fiber glass reinforced canvas sleeve shall be used.

All fans shall be protected and painted to avoid corrosion.

Lubrication
All blower bearings shall be provided with adequate facilities for lubrication. Exhaust fan unit bearings shall be sealed lubricated type. All oiling devices, grease fittings shall be readily accessible. All bearings shall be lubricated upon completion of the work using lubricants specified by the manufacturer.

Testing
The Contractor shall adjust, test and air balance the ventilating and exhaust systems and shall submit a report after final adjustments to 5% of designed air quantities.

Operating Instruction
Three (3) copies of an Instruction book giving complete service data on all equipment and system shall be furnished.

NOTES / PROVISIONS
Bidder to take note of following provisions applicable for specifications for various mechanical equipment.

1. See the "GENERAL REQUIREMENT FOR MECHANICAL ITEMS/EQUIPMENT" at end of equipment specifications for painting/coating, minimum documentation requirement for approval during execution and prior to manufacturing and inspection requirements.
2. For all imported equipment, the motors, gearbox, switchgear, PLC controls, etc. items and components as per manufacturers' standards and makes shall be acceptable.
3. For items like blowers, centrifuge/decanter, , electric actuator, mixers , etc. the motors, gearbox as per manufacturers' standards and makes shall be acceptable.
4. For items like screw pumps, dosing pumps, valves, gates, EOT Cranes/Hoist/Material handling equipment etc. the gear box as per manufacturers' standards and makes shall be acceptable.
5. Make of Crane Duty (S4) motor of small capacity (**≤ 5.5kW**) for EOT Crane/Electric Hoist as per manufacturers' standards shall be acceptable.
6. The construction and general requirements for starter/control panel supplied by vendor along with equipment (applicable for equipment with max. motor rated **≤ 15kW**) can be accepted as under.
    - The control panel shall be generally be free standing, floor / wall mounting type, totally enclosed and dust, damp and vermin proof. Enclosure shall have IP-42/IP-52 or better degree of protection to be mounted indoor or under shed with suitable protection unless better protection class specified in specifications of respective equipment or in BOQ or in tender specifications elsewhere (such as Scope of Work or Process Description or Process Design Criteria and Detail Specifications etc.). Cubicle sheet steel shall be CRCA minimum 1.6mm for load bearing and non-load bearing members. Gland plate shall be CRCA sheet minimum 2.0mm thick unless higher thickness or better MOC (SS 304 or such better MOC enclosure) specified in specifications of respective equipment or in BOQ or in tender specifications elsewhere (such as Scope of Work or Process Description or Process Design Criteria and Detail Specifications etc.).

For motors rated **≤ 15 kW**, the common equipment panel with multiple starters up to 6 numbers within single cubicle can be accepted. However for motor rated >15 kW, individual starter cubicle only shall be provided. For panel offered with multiple starters, the main incomer breaker shall be MCCB of suitable rating.

- Starter shall be fuse less type. Incomer shall be with ammeter, voltmeter, indicating lamps etc. Start/Stop (Mushroom head stay put type with padlocking facility)/Overload Reset Push Button and Auto-Off-Manual, local-remote selector switches etc. shall be provided. Ammeter with Y-Phase CT shall be provided for all starters with motors rating **ranging from 7.5 kW to < 30 kW,** and ammeter with selector switches shall be provided for all starters with motors rating of **≥ 30 kW**. Control and power wiring shall be with minimum 1.5 sq. mm. FRLS Copper flexible. CTs, wherever provided shall be resin cast.

  The breaker (MCCB/MCB) and other switchgear (MPCB, contactor etc.) shall be as per approved makes specified in tender/specifications for electrical works except for panels imported from outside the country for which makes as per manufacturer standard shall be accepted. However makes of rest all items like wires, selector switches, push buttons, CT/PT, etc. as per manufacturers' standards are acceptable.

- For equipment starter required with/provided with VFD based starting or with Soft Starter based starting following to be noted:
  - ✓ VFD shall be selected such that the de-rated current of VFD/Soft Starter for 50 ^{0}C continuous operating temperature shall be equal to or greater than 110% of the rated current of driven motor. Alternatively, VFD shall be provided of at least one rating higher than the motor rating.
  - ✓ The VFD for sewage/STP and industrial effluent or such application shall be with 3C3 conformal coating and for raw/drinking water or rest applications shall be with 3C2 conformal coating.
  - ✓ The Fast Acting (Semi-conductor) fuse for VFD/Soft Starter protection are not required for motors rated less than **75 kW**.
  - ✓ The series contractor in line of VFD/Soft Starter after breaker is not required for motors rated less than **75 kW**.
  - ✓ VFD shall be with communication port (RS 485 Modbus or suitable) and shall be connected with plant PLC/SCADA for remote data, power monitoring and diagnostic data.

- Shall be suitable for remote monitoring and control from PLC/SCADA system. Required potential free contacts shall be provided for On/Off, Trip and L/R selector switch status as a minimum. In case of PLC based control offered, the PLC shall be with communication port (Modbus protocol or suitable) to communicate with plant/main PLC/SCADA for remote monitoring and control.

- For PLC based control provided in control panel supplied along with equipment by vendor, the PLC with specification and make as per manufacturers' standards are acceptable.

- Bidder to refer the specifications for electrical works and instrumentation works for rest all requirements.

7. The detail specifications for various mechanical equipment provided below are general specifications/general requirements. Operation philosophy and construction methodology may vary for each manufacturer and for the type of equipment offered and can be accepted keeping the design philosophy/application requirement as specified in tender or as per process requirement and such minor variation in specifications can be accepted subject to review (if required with justification/supporting documents) and Client's approval.

DETAILED MECHANICAL SPECIFICATIONS FOR VARIOUS EQUIPMENT

❖ SPECIFICATIONS FOR CLARIFLOCCULATOR MECHANISM (ROTATING BRIDGE TYPE)

Design and construction requirements:
Clariflocculator mechanism shall be suitable for installation in RCC tank (newly constructed or existing as applicable) as per following specifications. The tank **shall have a central area for coagulation and flocculation and outer area for clarification settling.** A partition wall in RCC construction separates the flocculation zone from the clarification zone.
General design criteria shall be as under:

A. Clariflocculator

Description	:	**Parameters**
Floor slope	:	1:12 or as per tender specifications
Inside dia of clarifier	:	As per Design
Location of launder	:	As per Design
Weir loading	:	12.50 M^3/M/hr. Max. or as per tender specifications
Outlet arrangement of the clarified water	:	90^0 8 mm thk. FRP (or of MOC and thk as per tender specifications) adjustable V notch weir plate, min. 300mm Ht. and min. 100mm slot for weir height adjustment, to be fixed along the periphery of the clarifier tank as per hydraulic design calculations
Clarifier Bridge with wheel assembly	:	Min. 1200 mm clear width in to in
Peripheral speed of Scrapper Arm	:	1 - 3 cm / sec
Thickness of scrapper Blade	:	6 mm (Min.)
Thickness / Size of Rubber Squeezes	:	Min. 10 mm thk x 100mm or suitable Ht.
MOC of Bridge and Scrapper	:	MS, IS 2062, epoxy painted. All hardware, nuts and Bolts (wetted / submerged and non-wetted) shall be of SS– 304 Material.
Painting	:	Epoxy paint as per specifications.
Telescopic Bleed valve	:	1 set for each clarifier s a standard. If more than one sludge withdrawal line, one set to be provided for each sludge withdrawal line / chamber. Inlet telescopic line to be provided with isolation valve (Sluice / knife gate valve). sludge line and overflow / return line from chamber to be provided with isolation valve, normally open.
Water flushing connection for each sludge withdrawal chamber / sludge withdrawal line	:	2 nos., 50mm dia. with isolation ball valve and flanged entry with blind flange, one on each side of sludge withdrawal valve of sludge withdrawal line, each on upstream and downstream side of sludge withdrawal valve.
Railing	:	MS pipe / structure railing with epoxy paint.
Sludge Drain Valve for each sludge withdrawal line / sludge withdrawal chamber		1 Nos. with extended spindle valve (shall be electric actuator operated if specified in tender specifications elsewhere or in BOQ/SOQ),

Description	:	Parameters
		minimum 300 mm diameter (or of size as specified in tender specifications elsewhere or in BOQ/SOQ) straight to drain chamber. The actuator shall be above ground level connected with extended spindle.

B. Flocculator

Type.	:	Set of counter rotating flocculator blades
Flow	:	As per design
Qty. of Flocculation Paddles / Flocculators	:	4 Nos. / 2 Nos. can be accepted for clari-flocculator (clarifier) diameter of up to 25m
GT Value	:	10,000 – 1,00,000
MOC of Flocculator / paddles	:	MSEP
Service factor for gear box	:	2.0 (Minimum).
Size	:	As per Design / For existing tank the size to be verified at site by vendor

Rotating Half Bridge

The bridge in welded steel construction shall span half the tank diameter and further beyond center in the direction of the walkway. The truss bridge shall be with clear 1.2 M width with walkway of MS grating suitable for load carrying capacity specified except for the portion of each drive and panel area where min. 5mm thk or higher size chequered plate shall be provided all around the drive area and at least 1m on either side from panel for panel area (alternately entire walkway shall be provided with chequered plate of min. 5mm thk or higher suitable for load carrying capacity specified). The bridge is pivoted at the center on a slewing ring bearing and is attached to a trolley with Cast Steel (CS) wheels moving over billet (steel rail) or steel plate / flats (as specified in BOQ / tender specifications elsewhere) mounted on the peripheral wall of the clarifier. A drive assembly located on the trolley and coupled to the trolley drive wheel through chain & sprocket arrangement rotates the bridge about the center of the clariflocculator.

It shall be provided with:

- Central platform for the installation of the stirrers (flocculation paddles) and their drives and for the local control panel;
- Paddle stirrers / agitators for slow mixing of the incoming raw water in the central unit;
- A radial scraper system with bottom scraper blades, suspended on the bridge.

The scrapper and rotating bridge shall be of MS construction. Handrails shall be of 40 mm. dia. MS pipe size medium grade / suitable structure steel member size.

The rotating bridge structure shall incorporate a walkway having a minimum effective width of 1200 mm which shall be surfaced with M.S, chequered plates or gratings with chequered plates as specified above, painted black. The bridge shall be designed to take its own dead weight together with uniformly distributed loading of 250 kg/m^2 over the full span and width of the walkway bridge and a moving point load of 500 kg. Maximum deflection of the bridge under the specified loading shall not exceed 1/360^{th} of the span. The **positive camber shall be kept** initially to compensate for the maximum deflection under dead weight and superimposed loads.

The bridge shall be so braced as to limit lateral deflection to less than 80 mm measured at mid span under a full load condition.

The central part of the bridge shall be large enough for the installation of the flocculator systems and the control panel.

The bridge shall have hand railing to both sides forming an enclosure at the centre in between. The finished height of the railing shall be min. 1.0 m above the walkway. Toe guards shall be provided and secured around the bridge walkway which shall not be less than 100 mm high and min. 3 mm thick.

Bridge Support and End Carriage
The bridge structure shall be supported at the center of the clariflocculator by means of cast iron bearing assembly of the slewing ring type and incorporating trunnion type mounting to accommodate vertical undulations of the traction wheels at the peripheral wall of the tank. The central bearing assembly shall be adequately lubricated and all grease points shall be extended to a battery plate 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 draining the system. Catch drains shall be provided under all oil and grease point 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, whilst providing the suitable base for the motors, gear box, driving and idling wheels, shafts and bearings. The wheels shall be such that a de-railing cannot occur due to some misalignment. The size and design of wheels and carriage shall be calculated to transmit optimum tractive effort relative to the proportions of the scrapper without producing wheel spin when the wheel path is subject to the climatic conditions.

Center Bearing Assembly
This shall essentially consist of a slewing ring bearing assembly that shall be located by an MS platform and center tube. The platform shall be supported on the RCC center pier.

Slip ring Assembly
The slip ring assembly shall be mounted above the top level of the tank walls. Sufficient rings (Min. 12 nos. slip rings) shall be provided for power cable and control cable for remote monitoring and control from **ICP / PLC /** SCADA and as specified in Process Design Criteria & Specifications or Scope of Work or Description of Project or elsewhere of tender specifications. However, if specified to provide only the power cable then min. 7 Nos. slip rings shall be provided. Slip ring assembly shall be provided at the center of the clariflocculator above the center bearing assembly for supplying power to a distribution board to supply power for four (4) nos. flocculator drives and one (1) no. bridge drive. A distribution board is provided on board the clariflocculator bridge for distributing power to the five (5) drives from one incomer. Common status of the units shall be provided to main control room and possible to start and stop from remote location / PLC & SCADA control if specified elsewhere in tender / BOQ / SOQ.

The slip rings for power portion shall cover the motor supply (R, Y, B, E and N generated in control panel or to be provided from outside as per requirement). For remote monitoring and control where specified the slip rings shall be provided to cover ancillary circuits with common status of drive and flocculators units like ON/OFF, Trip/Fault, A/M status for status monitoring and common start and stop command for remote operation / control.
For smaller diameter clari-flocculators as specified above for which 2 nos. floccualtors are considered, the slip ring quantity shall be reduced proportionately.

Drive Unit
This traction unit shall consist of a driving and idling wheel assembly.

The bridge drive shall comprise of either (a) motor with reduction gear, a chain sprocket or (b) a geared motor. The assembly shall be rigidly mounted and shall be adequately rated for continuous service in water treatment works environment.

Both the drive and idling unit shall be fitted with suitable diameter CS wheels and shall be carried on the respective shafts supported on anti-friction bearings.

The wheels shall travel on the clariflocculator wall over steel billets (steel rail) of size as recommended by vendor as a standard unless otherwise / other methodology specified in BOQ / tender specifications elsewhere (such as Scope of Work or Process Description or Process Design Criteria and Detail Specifications etc.). The steel billets shall be fitted / welded over insert plates of required size and thickness provided on top radially across walkway by a radial distance of about 1-1.5m inserted in concrete during civil works.

If BOQ / tender specifications elsewhere specify for wheel moving over steel flats (MS Flats) along the periphery mounted on top of the clariflocculator wall instead of steel billet then in this case the MS flats (rails) shall be min. 300mm wide and min. 12mm thick supported / welded over MS insert plate of min. 350mm or required width & min. 10mm or required higher thickness.

Insert plate (for either of steel billet / MS Flat options) shall be provided on top radially across walkway by a radial distance of about 1-1.5m inserted in concrete during civil works on which the peripheral wheel shall move.

If BOQ / tender specifications elsewhere specify for wheel moving directly over top of peripheral RCC wall, then in this case the CS wheels shall be with PU coating. The top of wall shall be finished such that top of wall is in proper level without nay undulations for smooth movement of wheels over the wall.

The mechanism shall be driven by adequate HP motor mounted on the periphery of the bridge

All lubrication points, all necessary provisions shall be made for routine maintenance and for prevention of oil and grease spillage. A deflector shall be provided and fitted to the leading edge of the driving carriage. It shall be angled at 45º and arranged to be adjustable within 3 mm of the perimeter rail such that material coming in the way of free passage of the wheel shall be deflected.

Floor Scraper, **Blades and Fixtures**

Scraper shall be suspended from the bridge at various points across the bridge length covering half the diameter of the tank. The scraper blades shall be manufactured from MS fitted with renewable rubber squeegees and attached to steel arms suspended from the bridge.

Scrappers shall be suspended and arranged to give continuous and progressive scrapping of the entire floor of the clariflocculator and the swept area of the successive blades shall overlap. The configuration of blades shall be designed to carry sludge and deposited suspended solids from the periphery of the tank and deposit it efficiently in the withdrawal hopper / sludge pocket.

The number and length of individual blades shall be designed by the vendor, but the depth shall not be less than 300 mm and the thickness not less than 6 mm. Renewable fabric reinforced rubber wearing strips of cross section not less than 12 mm x 100 mm shall be fitted to each blade to provide a continuous contact surface which is adjustable for wear. The material shall have hardness not greater than 40 and be manufactured from well-proven compound.

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. Appropriate washers shall be fitted beneath all bolts head and nuts.

Flocculation Zone

The flocculation compartment shall be of RCC construction concentric to RCC clariflocculator tank.

Four (4) nos. flocculation paddles shall be suspended from the bridge, one on each side of the center pier in the direction of bridge and one each in direction perpendicular to the bridge (2 Nos. in case of small diameter tanks as specified above, suspended from the bridge in opposite direction as per vendor design). The area of paddles shall be 10 – 15% of the cross sectional area of the flocculation zone. These shall be supported from the rotating bridge. Shaft and impeller blades of flocculator shall be of MSEP material. The motor HP shall be as per design.

Overflow
The overflow from the clariflocculator shall be collected through adjustable 90Deg V-notch 8 mm thick FRP weir (or of MOC and thk as per tender specifications) to be provided along the peripheral wall of clariflocculator of min. 300mm Ht. and with 100mm Ht. slot for vertical weir adjustment. The weir plates shall be fixed with stainless steel anchors, nuts and washers.

Local Distribution Board, Motors, starters and control
The bridge drive and the flocculators shall be controlled from an **outdoor panel in SS-304 housing** (double door) suitable for outdoor installation installed in the central part of the bridge. The drive status indicating lamps and required on & off push buttons, Emergency Stop PB with padlock facility, A/M selector switch for remote monitoring and control requirement if applicable, etc. shall be provided on this control panel. Canopy for panel shall be provided if required.

A local distribution board (SS enclosure suitable for outdoor installation) shall be furnished along with the mechanism for distribution of power to the peripheral drive motor and motors for flocculation paddles.

The electrical supply to bridge or flocculator driving motors 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 bridge and shall be complete with all necessary support bracket, anti – rotation device. A suitable means of lubrication shall be provided.

Bridge drive and flocculator motors shall be of squirrel cage type, protected and shall be rated at least 30% above design duty and shall meet the specifications of motor mentioned under electrical section.

All cables shall be connected to a termination box at the wall of the clariflocculator. From there, cables are connected to the main control panel. Common status like drive status and trip signals shall also be fed to PLC for suitable alarm and tripping / stopping of the drives.

The electrical equipment shall comprise of:
- Incoming cable (4C/5C power cable and control cable as applicable as per tender specificaitons / BOQ) to be laid separately in 2 nos. heavy duty uPVC / GI pipe lines of min. 100mm dia. (with dual draw wires or suitable arrangement for pulling cables to top of centre column) with sufficient slip ring contacts (Min. 6 Nos. if only power cable to be provided and with min. 12 nos. slip rings if power cable and control cable for remote monitoring and control from ICP / PLC / SCADA required) for the on-board power supply and the supply of all motors & other remote control & monitoring requirements;
- On-board local control panel in SS housing suitable of outdoor installation;
- Drives for the flocculator stirrers;
- Drives for the bridges;
- Emergency mushroom type stop buttons with padlocking at the control panel and at LCS the outer side of the bridge;
- Lighting.

Refer the "Notes/Provisions" in under general specifications for mechanical works and electrical specifications for control panel and other general requirement/specifications and makes as applicable.

Telescopic Valve Arrangement
One no. Telescopic valve arrangement shall be provided to sample the sludge for quality check purpose from the sludge withdrawal pipe as a standard.

In case where two or more sludge withdrawal lines as specified in tender specifications / BOQ / SOQ telescopic valve arrangement shall be provided for each sludge withdrawal line separately.

The telescopic sludge withdrawal line to be tapped from sludge withdrawal line shall be provided with isolation valve (Sluice or knife gate valve). The return sludge line from telescopic valve sampling chamber to sludge withdrawal pipe line shall also be provided of min. 150mm dia.

Min. 50mm dia. Flushing line (MS Med. Duty) with blind flange or suitable end connection to connect with plant service water supply line. This flushing line shall be connected to sludge withdrawal line on both the upstream and downstream side of sludge withdrawal valve and each of this line shall be provided with isolation ball valve in SS-304 and with flanged end for pressurized flushing and chokage removal on either side.

NOTE: The above specification and MOC are minimum and higher or better MOC and specifications shall be provided if specified elsewhere in tender specifications (in Process Design Criteria & Specifications or Scope of Work or Description of Project or elsewhere of tender specifications) or in BOQ/SOQ/Price Bid.

❖ SPECIFICAITONS FOR TWIN LOBE AIR BLOWERS (ROOTS TYPE)

Air blower shall be designed to perform satisfactorily under specified start up condition, part load / full load operation, max. differential pressure operation and relief valve setting pressure and up to trip speed. All the compressor casing shall be air cooled type for up to 5500mmWC discharge pressure / water cooled type or with after cooler for more than 5500mm WC discharge pressure unless specified otherwise elsewhere in tender.

The blower vendor shall provide performance curve/s of the offered blower including the following as a minimum:

- maximum, minimum and intermediate speed curves

Blower manufacturer shall also incorporate the mass flow at rated duty conditions when air used for process control (Aeration Tank or such application). The data sheet shall also include minimum and maximum speed, minimum and maximum flow, turndown ratio of offered blower (flow reduction possible at rated pressure), BKW at rated and at turndown point, etc.

The design parameters to be considered are as under:

	Blower Design Parameters:	
a	Min. / Max. air inlet Temperature	5 / 45 Degree C
b	Design RH	65%
c	Altitude	As per Site Location
d	Capacity (Nm3/hr) – at Discharge	As per design / process requirement, Nm3/hr (defined @ 0 degree C, 1.013 bar & 0 % Rh)
e	Head / Disch. Pr. (Kg/cm2)	As per design
f	Speed of blower	1200 RPM (max.)

Air blower shall consist of the following accessories:

- Twin lobe compressor
- TEFC Squirrel cage induction motor as per electrical specifications & of approved make. Motor for VFD operated blower shall be of VFD duty.
- Suction Filter
- Suction / discharge silencer
- V belt & V belt guard
- Motor pulley & compressor pulley
- Slide rail
- Common base frame
- Safety valve
- Anti-vibration pads
- Pressure gauges – Bourdon type, 150mm dia., SS casing, glycerin filled with manifold valve, syphon and snubber, etc. & of make as per specification for instrumentation work.
- The blower noise level shall be within 85 dB (A) at a distance of 1.86m. If noise level exceeds without hood then acoustic hood shall be provided to meet this requirement.
- Acoustic hood comprising of fabricated 50 /mm square welded tube /100 mm thickness as inbuilt wall (as per manufacturing Std) , frame, acoustic insulation of glass wool of density 30 kg3/m2 and perforated sheet on inside face and MS sheet on outside face in welded construction – as per requirement to limit noise level within limit as specified.
- Inter connecting piping comprising of discharge butterfly valve, flap/ Wafer type non-return valve, and metallic expansion bellow. Bidder to refer specification for mechanical work for rest specifications and make of valves and bellows. Additionally the MOC of bellows and valves / internals shall be suitable to withstand the temperature at discharge of blower considering the temperature rise at delivery of blower over design ambient of 50 degC.
- Any other required accessories and protections for satisfactory running of blowers.

Material of construction of various part of the air blower shall be as under:

Casing	:	CI-FG-260, IS:210
Lobes	:	SG Iron 500/7 IS 1865
Shaft	:	En 19 /EN 24 BS:970 Part-1
Gears	:	EN-353 case hardened and ground
Common Base Frame	:	MS Fabricated

❖ SPECIFICATION FOR CHLORINATION SYSTEM – VACUUM TYPE, FLOOR/WALL MOUNTED

Type	:	Vacuum Type Solution Feed, Floor/Wall Mounted
Turndown Ratio	:	Minimum 10:1 over full range of operation
Electric Power	:	415V ± 10% 3 Phase 50 Hz.

General Description

The Chlorinators are required for the disinfection and treatment of municipal and industrial water and wastewater.

The Chlorinator equipment shall be designed to ensure maximum safety of operating personnel and equipment. The Chlorine gas control system shall operate under vacuum to prevent gas leakage

In general, the Chlorinator operates under a vacuum that is produced at the ejector and transmitted through the control unit to the vacuum regulating valve located at the gas supply. Gas enters the vacuum regulating valve and moves toward the flow control components under a vacuum. Gas next passes through the Rota□meter, where its flow rate is measured and the V□ Notch orifice, where feed rate is controlled manually or by an automatic positioner. At the injector, the metered gas is dissolved in the water stream. The resultant Hypochlorus solution is discharged to the point of application. Feed rate of Chlorinator shall be controlled by either one or both of these methods: interrupting the injector water supply to shut off the Chlorinator's operating vacuum; changing v□notch□orifice area (by positioning the v□grooved plug in its ring) while holding vacuum differential across the orifice constant.

Chlorinator shall be Vacuum Type Solution Feed Floor/Wall Mounted Chlorination system consisting of a Floor/Wall mounted cabinet with in-built chlorine flow meter with chlorine rate control valve, interconnecting vacuum piping, with Remote vacuum regulator, Remote injector with primary check valve, vent and vacuum tubing, yoke clamp, etc. complete in all respects and with highest safety standards and meeting all latest regulatory requirements.

The Chlorinator of up to 10Kg/Hr. capacity shall be floor/wall mounted type whereas Chlorinators of more than 10Kg/Hr. capacity shall be floor mounted type only.

The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.

Chlorination system including all main parts, sub parts, bought out items shall be designed to conform to latest IS: 10553 Part B (1983) and other applicable national/international standards.

This scope of work covers the complete design & engineering, manufacturing, performance testing, delivery, installation and commissioning of Chlorination system. The complete chlorination system & plant shall comprise the union connecting to the cylinder/drum valve up to and including the final dosing point and including chlorine containers (toner/cylinder) as specified in tender and any other as required for making the chlorine plant working in all respect and whatever needed to make the plant operational shall be included, no extra claim for the same on later date will be considered.

DESIGN & OTHER REQUIREMENTS

All pressure gauges shall be provided with isolating valves.

The suction velocity for booster pump shall not exceed 1.5 m/sec and velocity in the pressure water lines shall not preferably below 2 m/sec. but not exceeding 2.5 m/sec in any case.

Gas filter shall be capable of holding all the solid particles with readily removable glass wool cartridges or equivalent materials.

Chlorine stop valve shall be as per IS: 3224 isolated from the gas and shall have needles and seats of easily replaceable type.

Gas flow meters shall be calibrated in metric units.

All components in contact with chlorine shall be of suitable material to withstand corrosion.

All spring shall be used in the vacuum regulator shall be tantalum alloy or hastelloy.

<u>Each Chlorinator Set shall consist of following components as a minimum.</u>

- Floor/Wall mounted Front operated Cabinet of suitable MOC,

- Vacuum Regulator (regulator shall incorporate a positive chlorine gas shut□off valve, a pressure relief valve, and an excess vacuum shut□off valve),
- Injector/Ejector Assembly with Check Valve,
- Chlorine Flow meter Flow Rate Indicator (Rota meter mounted on cabinet),
- Chlorine Rate Control Valve, manually operated for chlorine gas flow increase/decrease (mounted on cabinet) (in case of auto dosing specified in tender, this valve shall be kept fully open),
- Differential Pressure Regulator (mounted on cabinet),
- Secondary Check Valve (mounted in cabinet),
- Drain Valve (mounted on cabinet),
- Vacuum and vent tubing as per requirement and
- Vacuum Gauge (mounted on cabinet)

Each Chlorinator Set shall have following accessories as a minimum.

- CS Manifold suitable for required quantity of Chlorine Tonner/Cylinder connection and of minimum 18mm Sch. 80 CS pipe (high grade seamless carbon steel, SA 106 Gr. B SCH 80 pipe) or higher size to suit Chlorinator capacity - 1 Lot.
  Pressure regulating valve shall be provided with each manifold if required.
  The manifold design philosophy shall be as under.
  - The manifold shall be designed to connect no. of cylinders/tonners to meet total capacity requirement considering maximum 1% drawl rate per cylinder/tonner capacity (i.e. 1 Kg/Hr. in case of 100Kg cylinder and 9 Kg/Hr. in case of 900 Kg tonners or maximum up to 10Kg/Hr. for 900Kg tonner if permitted by Chlorination Vendor ensuring satisfactory operation of Chlorination System) and accordingly considering no. of cylinders/tonners required for the rated/design capacity of Chlorinators e.g. For 15Kg/Hr. chlorinator connected to 900Kg tonner and considering drawl rate of 1% will require two tonners to be connected to manifold per chlorinator.
  - One to one connection shall be provided between each manifold and its associated chlorinator with interconnection valves between each manifold header for diverting flow to adjacent system if required.
  - The manifold design and provision shall be as specified above and the actual no. of tonners/cylinders to be connected shall be as specified elsewhere in tender/BOQ or as per client requirement.

- 2 Nos. isolation valves shall be provided for each toner/cylinder connection, one at manifold header side and other as auxiliary isolation valve for toner/cylinder side. The auxiliary valve on toner/cylinder side shall be installed on the chlorine tonner/cylinder valve to minimize operation of the chlorine container valve.
- Required copper tubing for each chlorine toner connection to its associated manifold and connected with auxiliary isolation valve on tonner side and header valve on manifold side. The flexible container connector shall be of 3/8" dia. cadmium plated, arsenic free annealed copper tubing with PVC sleeve or suitable protection. Minimum 2 nos. or higher numbers as required washers of lead with antimony shall be provided with each tubing.

- CS Gas filter (Moisture Trap), 1 No. for each gas manifold. In case of single manifold where permitted as above for up to 3Kg/Hr. chlorinator the gas filter shall be provided in 2 Nos. (1W + 1S) connected in parallel with inlet and outlet isolation valves for each filter. Filter shall have CS or suitable Body and filter element shall be removal cartridge type woven glass fiber and activated alumina or such suitable. Filter element holder shall be of finer material like Monel.
- Required No. of Isolation Valves for CS manifold as per IS: 3224 (tonner connection, manifold interconnection etc. as applicable.
- 2 Nos. Chlorine Pressure Gauge (Monel wetted part MOC only) on each manifold on inlet and outlet of gas filter (permits to check gas pressure as well as chokage of filter), Bourdon

type with Monel wetted parts, SS 316 Body, IP 65 Protection Class, Dual scale calibration shall be provided on each manifold. Chlorine pressure gauge with diaphragm seal can also be accepted with wetted parts as specified.

- Pressure reducing valve shall be provided on each manifold if required as per chlorinator vendor design/requirement for satisfactory and safe operation of chlorinators.
- Water Pressure Gauge On Ejector Inlet.
- Isolation ball valves on Inlet & Outlet of each Ejector of suitable size - 1 set for each plant.
- Isolation valves on Suction & discharge side and NRV on discharge side of each booster pump of suitable size - 1 set for each plant.
- Y type strainer on suction side of each booster pump of suitable size.
- NRV on ejector outlet line of suitable size.

All isolation valves for chlorine application shall be as per IS: 3224.

Each set shall also comprise of all std. accessories, sub assembly that is required for smooth operation of chlorinator and to complete the system In addition to above following shall be supplied in quantity as specified as a minimum or higher as required to complete the system:

- Centrifugal Booster Pumps of adequate capacity/rating of suitable type and MOC, minimum 1 No. with each chlorinator or higher number as specified elsewhere in the tender. MOC of pump set must be of CI body and impeller or better MOC with latest standard and suitable for chlorine application. Sizing calculations for the flow and head of the pump shall be submitted by vendor which shall be suitable for satisfactory operation of chlorination system. GA Drawing, Technical Data Sheet & Performance Curves of the pumps shall also be submitted for approval.
- Required length of uPVC piping and pipe fittings, Valves, NRV, Strainers etc. for connecting suction and delivery piping, as applicable, including interconnecting pipe/valves at delivery side of booster pump to chlorinator and main piping to feed water to any chlorinator. One to one piping shall be provided between each booster pump and its associated chlorinator with required interconnecting pipe and valves at discharge manifold to interchangeability of pumps flow to adjoining chlorinator.
- Diffuser – as per design & requirement, 1 No. of higher as specified elsewhere in tender.
- Suitable size of uPVC pipes and fittings for chlorine solution in required length to connect all associated chlorinators with provided nos. diffusers along with all inter connecting valves at both ends – 1 Lot.
- MS Skid as required – 1 Lot.
- Necessary automatic safety devices like gas-off etc. in case of emergency like failure of power, water supply, should be incorporated. Further safety devices for backwater entry in chlorinator due to failure of NRV should also be incorporated, as applicable.
- Isolation valves at manifold header to interconnect all booster pumps
- The system shall be constructed of materials suitable for wet or dry chlorine gas service. All vacuum connections & raw (booster) water & chlorine solution lines shall be of **Schedule 80 uPVC as a minimum or better** with required specials as per application requirement.
- Chlorine Tonner lifting beam as per ASME B30.20 with crane weighing scale / lifting hook with suspended weighing scale to weigh tonner (not applicable for chlorine cylinder).
- Any other piping, valves, accessories and other components, etc. as required to complete the work and for satisfactory operation of complete chlorination system and to meet the operational requirements as specified in the tender.

In case of manual dosing, the dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10mg/l scale and a manual dose setter over the complete range. In case of auto dosing if specified elsewhere in the tender specification, an electric/servo motor actuator operated control valve (flow proportionate valve) shall be provided at chlorine line/vacuum line of each chlorinator to operate in closed loop control based on 4-20mA of such signal from the free

chlorine transmitter or such suitable feedback and shall have manual override facility to operate the system manually in case of automatic valve or dosing system malfunction/ failure.

In case of auto changeover of tonner/cylinder battery specified elsewhere in tender specifications/BOQ, the change to the standby tonner/cylinder battery shall be carried out automatically in the event of duty tonner/cylinder battery getting empty. When the pressure in the duty chlorine tonner falls to less than 1kg/cm^2 the automatic change over device with suitable type of actuator shall operate to isolate the empty tonner battery and to bring the full standby tonner battery on line. In this case two nos. manifold shall be provided in 1W + 1S configuration with each manifold capable of connecting the tonners/cylinders for total working capacity of chlorinators at specified drawl rate. This is general requirement and in case of very high capacity or high no. of chlorinators (more than 2W/more than three chlorinators including working & standby) the design can be finalized mutually between the Client and Vendor considering operational requirement and suitability for client and to achieve the objective of continuous chlorination without need to take shutdown in case of emptying of any one battery of toner/cylinder.

The chlorinator shall be generally as per IS: 10553 (Part 2) of 1983 and Chlorine Institute of USA and suitable to provide continuous and constant measured quantity of gas while in operation. Intermittent start or stop control or automatic shut off of chlorine shall be possible in case of leakage in the piping or interruption of water supply.

In the event of development of excessive gas pressure in the system due to any reason, it shall be safely vented. In order to vent off any excess vacuum, relief valve shall be included in the system, which will admit air to release any excessive vacuum, which may develop. The location of the vacuum relief valve shall be such that the air admitted in the system will not pass through flow meter. Therefore, flow meter will indicate only gas flow.

Safety devices as under shall be supplied as a minimum.

- Two sets of approved Breathing apparatus/gas mask with rechargeable respirators (self-contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with one 1200 liter capacity, 140mm diameter air tonners).
- Ammonia torch for leak detection.
- Four sets of safety clothing in various sizes, each comprising PVC overalls, Wellington boots with steel toe caps, goggles, gloves and safety helmets.
- 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.
- Vendor to furnish the list of additional safety accessories required as a minimum as per statutory requirement and shall supply the same.

Further following shall also be considered in scope of supply.

- Emergency safety shower and eye wash fountain
- Ton container repair kit
- Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Hindi/local vernacular language and in English.
- Residual Chlorine test kit of range 0.2 PPM to 5.0 PPM to color glass comparator type.
- Set of erection and maintenance tools including special tools and tackles.
- 900Kg capacity tonner confirming to BS 1500 Part 1 1958 for liquid chlorine sufficient for 15 days requirement or in minimum quantity as specified in Process Design Criteria elsewhere in this tender, whichever is higher or in quantities as specified in BOQ/SOQ of Price Bid.
  The same shall be approved from explosive Dept. of Central Government, permission to fill the tonner with liquid chlorine should be furnished. The container should be complete with first filling of liquid chlorine.

- Set of Roller support for each chlorine tonner connected with each of working and standby chlorination system provided within tonner room.
- Minimum 3 nos. chlorine leak detectors or higher nos. as required to suit tonner room area shall be provided in the chlorination equipment room for high and high-high level alarms and suitable safety interlocks. Chlorine gas leak detectors shall be provided each, with a single detector cell. At least two sensors or higher nos. as required shall be located in the chlorine tonner storage room and at least one sensor in the chlorination room. The chlorine leak detectors in the tonner room shall be mounted at suitable location in the tonner room to cover the entire area of room to detect any leakage.

  The chlorine leak detectors shall initiate a local audible and visual alarm and also provide potential free contact for remote alarm at control room. The chlorine leak detectors shall have two adjustable alarm levels sensitive to chlorine concentrations above 1 mg/m^3. At high level the ventilation fans shall be interlocked to start at high level. At high-high level alarm interlock shall be provided to stop the tonner room and chlorination room exhaust fans. Required relay/PLC based control panel shall be provided for the same. Pilot lights and warning sound generators shall be installed in outdoors to notify gas detection.

Sr. No.	**Description**	**Materials of Construction**
1.	Chlorine Gas Detector	Detection of Chlorine Gas Chlorination System. Detectors shall have facility for replacement of sensors. Detector housing unit shall be with mounting assembly etc. Detector transmitter shall have provision for interface with configuration device
2	Model	Vendor to specify
3	Operating Principle	Electrochemical Cell
4	Range	0-10 ppm
5	Overall Accuracy	± 5% of FSD
6	Output Signal	4-20 mA, with option of source/sink of 0-10 ppm reading
7	Repeatability	± 5% of FSD or ± 5% of measured value or better
8	Response Time	80% response time of 60 seconds or less
9	Monitor	Microprocessor based with LCD/LED display. Four alarm LEDs, a 90dB audible alarm with alarm acknowledge and reset facility. One monitor with each detector
10	Power Supply	110V/230V, 50 Hz AC OR 24 V DC
11	Alarm	The two adjustable relays per sensor shall indicate high and high-high level alarm reading. The alarm relay shall be user selected as either latching or non-latching
12	Hazardous Area Classification	Class 1, Division 2, Group C, D
13	Type of Protection	Weather proof to IP 65/NEMA 4X
14	Transmitter Type	Provision of Local Display of PPM levels detected
15	Sensor Configurator	Bidder to offer 1 configurator complete with cables, adapters, power supply , operation & maintenance manual suitable for applicable hazardous area

- Neutralization pit suitable for two tonners/cylinders as applicable shall be provided if specified elsewhere in tender for water distribution station application. However for treatment plants (water/sewage/effluent) where chlorination systems are specified, neutralization pit shall be provided compulsory (even when chlorine scrubber is specified in which case neutralization pit will act as emergency standby). The pit shall be accessible by the overhead tonner handling system (crane/hoist as specified elsewhere in tender). The pit shall be surrounded with removable guard railing. The pit shall be kept full with a neutralizing solution of lime/20% Caustic soda solution. The pit shall be capable of holding side by side two chlorine toners. Provision shall be made to drain the pit.

Note: Above requirement shall be adhered to in all respects for EPC tender. However, in case of Item Rate/Percentage Rate Tender the scope/requirements specified as per financial bid/SOQ shall govern & shall supersede above details where in conflict.

❖ SPECIFICATIONS FOR FAIL SAFE PNEUMATIC ISOLATION AUTO SHUT OFF SYSTEM FOR CHLORINE CONTAINER (TONNER/CYLINDER) ROOT VALVE

The Emergency Shut off Valve/Device/System is intended to offer the highest level of safety when handling chlorine gas containers. Working in combination with a gas warning device (leak detector), the gas containers (tonner/cylinder as applicable) are closed within a few seconds (within 5 seconds of detecting leak trigger) as soon as a leak is detected reducing the total possible chlorine leakage time to offer the operating personnel a significant level of safety since the chlorine gas room does not have to be entered to close the gas containers. The purpose is to secure the environment and eliminating a possible leak prior to the trained operator entering the area to attend/manually re-open the chlorine gas valves. Vendor shall design/offer the system (device) generally meeting with The Chlorine Institute (CI) guidelines.

Equipment for the emergency cylinder valve closure system(s) specified herein shall be coordinated with associated equipment and devices as required to provide complete and fully compatible system.

The no. of valve/device shall be provided as per tender specifications/scope of work/process description /process data sheet/SOQ/price bid.

The auto shut-off device is intended to be installed directly on the chlorine gas valve of chlorine container (tonner/cylinder as applicable) and controlled from a control cabinet. The valve shall automatically close upon receipt of a closure signal. In case of more than one (multiple) auto shut off devices, all shall close simultaneously in the event of trigger/closure signal. It shall also be possible to test the valve periodically for functionality checking through test button/emergency switch by triggering it manually on the control cabinet located outside the storage/tonner or through local PB station provided at safe distance/area from tonner/chlorine storage room.

The auto shut-off device is to be specifically designed to close the cylinder or container valve(s) by using a pneumatic operated actuator directly coupled to the cylinder or container valve. The pneumatic operated actuator shall utilize compressed air or nitrogen as a source of operating gas.

The system shall use a bracket assembly that attaches directly to the cylinder or container valve and shall not require any support except on the valve. The system shall also avoid contact with the yoke and yoke adapter system. The system shall be designed to allow an operator to use a standard cylinder wrench to open the valve without removing the system. The system shall be designed to simultaneously close up all cylinder valves provided with auto shut off device when activated. For location provided with more than on auto shut off devices, systems that cannot close multiple valves simultaneously shall not be acceptable i.e. offered system should be able to close all connected shut off valves simultaneously in case of trigger/leak signal.

The selected actuator shall be adjustable or shall be with suitable closing torque to ensure that the correct, secure closure is achieved and vendor shall select accordingly.

The system shall operate even in the event of power failure i.e. an air receiver system for pneumatically operated maintained at required pressure and suitable battery backup system/UPS (minimum 2 hours battery back-up time) integrated in the control cabinet shall be provided to ensures that the device/s functions after pre-set time in the event of prolonged power failure. If more than one shut off valve/ device then the backup system shall be adequate to close/carry out at least one operation simultaneously for each of the total no. of valves provided in case of power failure.

The air receiver for compressor shall be provided with low and high pressure switches for automatic operation of compressor so that compressor stops at set high pressure and starts at low pressure. The low pressure set shall be adequate to ensure one or more shut off devices as applicable to operate/close simultaneously in the event of leak (trigger) or power failure. Further in the event of low-low pressure in air receiver (sensed by low-low pressure switch, to check condition of air leakage or such), an alarm flashed locally (and potential free signal or such shall be made available to hook-up with remote system at control room/SCADA room for remote alarm)

The chlorine gas leak detector for triggering the shut off valve/device action shall be provided as specified in chlorination system (or as per chlorine leak absorption system/chlorine scrubber specifications where this system is applicable/included in scope). If not specified elsewhere then the scope shall also include to provide minimum 1 no. chlorine leak detector or more to have at least 1 no. leak detector between 3-4 tonners (tonners provided with shut-off valve system).

The pneumatically operated auto shut off chlorine cylinder/tonner root valve shall be with pneumatic actuator, airline filter (AFR), Solenoid Valve, Yoke clamp etc. of required capacity, size, rating. The pneumatically actuated system shall also include and air compressor with air receiver of required capacity and at required pressure (including low and high pressure switches for automatic operation of compressor, starting on low pressure in air receiver and stopping when air receiver pressure reaches high set level), required air piping (uPVC Sch. 80) and air tubing.

The system shall be provided with PLC based Control panel for required monitoring, alarm (including hooter for local alarm) and operation shall be provided. PLC shall be with communication port (Ethernet with Modbus or such protocol) for remote monitoring. The scope also includes all required power, control and signal cabling.

Since this system is not continuously being operated, it is essential to operate the entire system including power back-up system periodically for preventing a possible malfunction of moving parts or power/ battery backup system. In general, it is highly recommended to check out the system weekly or bi-weekly as recommended by manufacturer.

The performance of the offered system shall be demonstrated at site/manufacturer works with required simulation.

Closure System Construction
The emergency cylinder valve closure system(s) shall generally consist of the following components.

- Pneumatic operated actuator capable of producing no more than 35 ft-lb of stall torque at 90 psig of operating gas pressure. The operating gas pressure shall be adjustable to provide 70 - 120 psig pressure range. The air requirement for offered pneumatic actuator/air motor shall be provided by Vendor along with offered actuator data sheet/catalogue from actuator OEM.

- Spring-loaded or such suitable coupler assembly to couple pneumatic operated actuator to the cylinder valve stem. Travel length of coupler assembly shall allow for varying lengths of cylinder valve stem. Coupler assembly shall preferably be an integral part of the pneumatic actuator.

- Bracket assembly to hold pneumatic actuator in place during closing of the cylinder valve. Bracket assembly shall be such to allow quick disassembly and shall not rely for support on packing nut or yoke assembly, or any other external support. Mounting bracket shall be fabricated from cadmium plated lightweight aluminium or such suitable material.

- A supply hose 6-foot or suitable in length and 3/8" inside diameter or such suitable dia. to suit actuator requirement and quick connect fitting shall be supplied for easy attachment of the pneumatic actuators to the operating gas source.

- A pre-assembled air control unit (AFR or such) shall provide filtered air that shall remove debris larger than 5 microns from the operating gas supply. It consists of the following installed components:

  - ✓ Operating gas pre filter: This filter shall remove debris larger than 5 microns from the operating gas supply. This filter shall be located in the operating gas supply line upstream from the solenoid valve.

  - ✓ Pressure switch: This pressure switch shall be of normally open configuration. Loss of operating gas pressure shall cause this switch to open and activate a corresponding alarm. Operating range of the pressure switch shall be adjustable.

  - ✓ Air Safety Valve: This valve provides protection for the solenoid valve. This is normally set for 125 psig or as recommended by SOV vendor.

  - ✓ Solenoid Valve: This valve shall be of normally open configuration. De-energizing the solenoid valve shall open the valve, allowing it to supply gas to operate the pneumatic actuators. This unit shall have 1/2" or suitable connections to accommodate field installation.

- Control Panel shall generally be as under.

  - ✓ The valve closure system shall be furnished with a local control panel with an enclosure to house the required controls. The control panel shall be mounted in the chlorine room or external of the chlorine room.

  - ✓ The control panel shall include the required switches and pilot lights, emergency stop, reset switch, alarm silence, supply power, gas pressure low, system ready and system activated, UPS battery low, UPS failure etc.

  - ✓ All control devices shall be mounted on the front of the control panel enclosure. Each control device shall have an engraved or etched nameplate describing its function.

  - ✓ The control panel shall have a terminal strip for connection of power and control circuits in the field. All terminals shall be numbered and terminal numbers shall be shown on the manufacturers wiring diagram.

  - ✓ Electrical connections of supply power, external alarm and control wiring shall be the owner's responsibility.

  - ✓ Online type Uninterruptible Power Supply (UPS) to be provided, wired and mounted preferably internal or external of the control panel. The UPS shall have a minimum 1kVA output power with no transfer time required. The UPS shall utilize "true" on-line double conversion technology.

- ✓ Uninterruptible power supply shall prevent the valve closure system from activating in the event AC supply voltage is removed or fluctuates. In the event of a sustained power loss, the valve closure system will get activated after a significant power loss and close the container valves. The back-up capacity of UPS shall also be checked periodically to ascertain the health of batteries/UPS System and the batteries shall be replaced periodically till the end of O&M period as required.

- Operating Gas Supply

  - ✓ The system owner shall provide operating gas supply, either compressed air or nitrogen.
  - ✓ The operating gas supply piping shall be 1/2" NPT or higher suitable to accommodate system components.
  - ✓ If nitrogen is used as the operating gas, owner shall supply a cylinder regulator on the cylinder to adjust nitrogen pressure to maximum 125 psig or as recommended by System Vendor.

The scope shall include all required piping, fittings, tubing and accessories etc. as required to complete the work in all respects.

DATA SHEET FOR AUTO SHUT OFF DEVICE/SYSTEM

PURPOSE	TO CLOSE CHLORINE TONNER VALVE ON Cl_2 LEAKAGE
LOCATION	CHLORINE TONNER ON ISOLATION VALVE
VALVE CLOSING TIME	5 SECONDS MAXIMUM
NO. OF DEVICE(S)	AS PER TENDER SPECIFICATIONS/SCOPE OF WORK/ PROCESS DESCRIPTION/PROCESS DATA SHEET/SOQ/ PRICE BID
OPERATION	PANEL BASED
BATTERY BACK UP	2 HRS.
TYPE	NON REVERSIBLE
OPERATING MEDIA	PNEUMATIC AIR
ENVIRONMENT	MOC SHOULD BE SUITABLE TO CHLORINE ENVIRONMENT
PANEL OPERATION	1) AUTO/MANUAL ON-OFF 2) GAS LEAK INDICATION/ALARM 3) EMERGENCY START FACILITY 4) VALVE OPEN/CLOSE INDICATION 5) AIR PRESSURE LOW 6) UPS POWER LOW 7) UPS FAIL 8) UPS POWER HEALTH/STATUS MONITORING
ACCESSORIES	1) COMPRESSOR 2) PNEUMATC ACTUATOR (ATLAS COPCO / POWEL OR EQUI. AS PER MFR. STD.) 3) SOLENOID VALVE, IP 65 4) FILTER REGULATOR COMBINATION - LUBRICATOR 5) CLAMP 6) INTER-CONNECTING PIPING/VALVE 7) HOOTER 8) PLC BASED LOCAL CONTROL PANEL WITH COMMUNICATION PORT FOR REMOTE DATA TRANSFER & MONITORING

Note: The above are general requirement and certain features may vary as per manufacturer design but shall meet the above stated objectives for emergency chlorine container valve closure in the event of gas leak.

❖ SPECIFICAITONS FOR AUTO CHLORINE LEAK ABSORPTION/NEUTRALIZATION SYSTEM (CHLORINE SCRUBBER)

System Description

The system should operate automatically in case of chlorine leak from container/tonner which should be covered by FRP hood with sensor. In case of chlorine leaking from the container/tonner, the system should automatically start i.e. blower and pump should start simultaneously. The pump should deliver NaOH from tank through the top of absorption tower and blower that should suck the leaked chlorine from FRP hood should push this sucked chlorine from bottom of absorption tower. Due to counter current flow of NaOH from top and Chlorine from bottom, chlorine is neutralized. After neutralizing chlorine, chlorine free air will be vented out in the atmosphere. Vendor has to guarantee that at the outlet of the system chlorine content will not exceed than 0.1PPM. Theoretically, on a weight basis, to neutralize one kg of chlorine with required 1.13kg of sodium hydroxide and will produce 1.05kg of sodium hypochlorite.

Scope of Work

The scope includes complete neutralizing system including all following main components but not limited to the same and other equipment necessary to make it fully functional as per the requirement and for safety purpose:

- Suitable FRP hoods/covers for Chlorine tonners with 900kgs of chlorine gas in each tonner (in case of chlorine cylinders, the hood shall be suitable for 100kg or applicable capacity cylinders as specified in tender specifications/scope of work/SOQ/price bid),
- Combined ducting with blower of suitable rating for evacuation of chlorine gas from any tonner,
- FRP scrubber unit, caustic solution circulation system with piping valves,
- Alkali circulation Pumps,
- Sensors/detectors for leakage of chlorine gas,
- Auto starting of the above system with manual override facility i.e. shall be able to operate automatically as well as manually with operator intervention and
- Electrical control panel

The spent scrubbing liquor shall be suitably disposed.

The scope of supply indicated above is a minimum quantity requirement. Any material quantity/service requirement for completing the job in totality will be in bidder's scope.

The broad requirement for major components shall be as under.

A. Split type FRP hoods for Chlorine tonners

- As per number of tonners/cylinders connected to system (in service & standby),
- Thickness 5mm(minimum),
- Suitable sizing nozzles, as per system design including connection to main header and
- Sliding Window for tube connection and operation.

B. Caustic Storage Tank

- Suitable for 20% w/w caustic solution and for operating temperature up to 80 degree C or higher as per process requirement as significant quantities of heat are released by the sodium hydroxide-chlorine reaction.
- PVC-lined FRP/FRP + PP or such suitable MOC and thickness as per system/manufacturer design.
- Vertical cylindrical with flat bottom Type Design.

- Capacity of tank to be adequate for absorption of chlorine leaked for one no. of completely filled chlorine container in service + 20% margin with minimum 300mm Free Board. However for chlorine cylinders or such low capacity system the tanks shall be of minimum 1000litres capacity.

C. Scrubber Column

a) Fluid handled capacity is 20%w/w (maximum) caustic solution and chlorine gas.
b) MOC is FRP+PP or such suitable and thickness as per system/manufacturer design.
c) Vertical cylindrical packed column type.
d) Capacity is Adequate for absorption of chlorine leaked from one no. of completely filled chlorine container (tonner or cylinder as applicable) in service in one hour (maximum).

D. Centrifugal Blower

- The design capacity should take the maximum probable gas flow into account considering to such air/gas from all connected tonners/cylinders to the hoods/scrubbing system.
- 2 Nos. (1W + 1S) suitable to handle entire chlorine gas as per capacity of tonner/cylinder from leaked container and capacity suitable to suck air/gas from no. of chlorine tonners/cylinders connected to the scrubbing system in one hour (maximum) or as per manufacturer design,
- Body and impeller MOC is FRP + PP/FRP with suitable lining or such non-corrosive/corrosion resistant material to suit chlorine application.
- Necessary Accessories like Common base frame, discharge damper, belt guard etc. as applicable.

E. Circulation Pump

- 2 Nos. (1W + 1S), suitable to handle 20% Caustic Solution and of capacity to neutralize chlorine gas leaked from completely filled chlorine container (tonner or cylinder as applicable) in service in one hour (maximum),
- Body and impeller MOC is PP or such non-corrosive/corrosion resistant material to suit chlorine application,
- Horizontal Centrifugal Type,
- Necessary Accessories like Common base frame, Valves, Coupling Guard etc.

F. Connection Piping & Valves,

- Duct Line MOC is uPVC (Sch. 40), size suitable to handle peak flow/design flow of blower,
- Caustic Line MOC is uPVC (Sch. 40) and
- Valve, Strainer, NRVs MOC is PP.

G. Instruments

All Necessary instruments to be considered by Bidders as mentioned below.

- Level Switches
- Level Indicators
- Temperature Indication
- Chlorine Leak Detectors. If leak detectors specified in chlorination system then the same in specified quantity shall be provided as a minimum and any additional as required/recommended shall be provided to cover the no. of tonners / area of tonners connected to scrubber system. Min. 2 nos. leak detectors or higher such that minimum one leak detector is available between every 4 tonners that are provided in tonner room/connected to scrubbing system.

H. Electrical Panel/Control Panel

- Required electrical panel with starters for all equipment meeting tender specifications (refer electrical specifications)
- PLC based Control panel for automatic operation of Blower, Circulation pumps etc. and for instruments monitoring, etc. with manual override facility. PLC shall be with communication port (Ethernet with Modbus or such protocol) for remote monitoring as well as control if required from remote location.

- AUTO/MANUAL Selection. The system shall be in auto mode in default to be able to operate automatically through leak detection trigger signal or if required to operate from control room remotely.
- Hooter with hooter reset PB to provide local alarm in event of chlorine leak.
- Necessary Push Button, Indication lamps etc. shall be provided.
- Suitable potential free contacts shall be provided in for remote monitoring and alarm for PLC/SCADA system (to be hooked up with PLC/SCADA system at central control room).
- The electrical & control panel shall be installed at safe distance/area away from tonner room and as recommended by chlorination/scrubber vendor to ensure operation of system manually in case of automatic operation failure for any reason.

The scope also includes:

First fill of caustic solution and any other consumables or items/chemicals required for satisfactory commissioning and operation of the system and also subsequent periodic fill based on shelf life or for condition specified below and as per requirement/recommendation of Chlorination/Chlorine leak dissolving system vendor or due to usage in case of leakage as applicable till the end of O and M period

The neutralization system is a safety device to be run when the chlorine gas is leaked. Since this system is not continuously being operated, it is essential to operate the system periodically for preventing a possible malfunction of rotating parts. In general, it is highly recommended to check out the system weekly or bi-weekly as recommended by manufacturer and including pH value testing of caustic solution. As Carbon dioxide (CO_2) will be absorbed by the caustic solution during such periodic testing of the system it is required that caustic solution of concentration and quantity as recommended by scrubber vendor considering 15 minutes testing time of scrubber system during periodic testing to be added into the caustic solution tank every year. Caustic solution of concentration and quantity as recommended by scrubber vendor also to be replenished if the caustic is depleted to low concentrations so that the pH drops below 12.

Chlorine sensors remain to be replaced once shelf life gets over. The cost of sensor replacement shall be considered in scope of Bidder till the end of O&M period.

❖ **SPECIFICATIONS FOR AGITATORS / MIXERS (FOR ALUM, DWPE, ANY OTHER CHEMICAL OR SUCH MIXING OR SOLUTION PREPARATION APPLICAITONS)**

The Agitator / Mechanical Mixing Device shall comprise of rapidly rotating blades mounted on a vertical shaft coupled to the gear box shaft through rigid coupling and driven through a suitably rated 1500 RPM (Max.) continuous duty electric motor TEFC with IP 55 protection operating through a suitable type of reduction gear box to ensure uniform dispersal of the chemical solution / keep the sludge in suspension.

General Specification

- Agitator component shall be designed to fit through agitator opening on tank manhole.
- Pressure containing part shall have minimum corrosion allowance of 3 mm.
- Gear unit
  - A worm or suitable type of reduction gear shall be provided with a minimum service factor of 1.5 on the driver rated KW.
  - V belt operation is not acceptable.
- Rigid coupling shall have tapered bores with key in nut arrangement and of suitable MOC as per application requirement. Alternately, flexible coupling can be accepted / selected with a minimum service factor of 2 and shall be capable of continuous operation at the max. anticipated misalignment if required as per vendor design.
- The shaft shall be suitable for transmitting full torque available for the rated driver. (Starting torque).

- Shaft shall be suitable for jamming conditions considering that rotor / impeller is jammed at 0.75 R from centre (R = Radius of impeller).
- Shaft assembly designed with critical speed at least 30% removed from any operating speed.
- Individual Impeller / Agitator blade shall be in one piece construction.
- Bearing housing shall be designed with a span suitable for the minimum radial cum thrust loading used for the design of the shaft.
- It is preferred that the design of the agitator does not incorporate the use of a steady bearing at the shaft end. However if the use of such bearing is imperative the design shall be such that the bearing is of self-aligning type and pre- lubricated.
- Mounting Stool and Support Steel Structure (epoxy painted) shall be provided for agitator and to suit tank size.

Mechanical Data:

Agitator type	:	Axial pitched turbine / low speed
No. of Blades	:	As per design
Impeller dia., mm	:	As per design
Gear box	:	Worm Gearbox or other suitable type as per vendor design
Agitator RPM	:	60-100
Shaft suspension Length	:	Suitable to Dosing Tanks Size / Depth.

Material of construction as min. as under or higher as indicated in BOQ / process data sheet or tender specifications elsewhere / as per process application requirement:

Agitator	SS 304
Impeller / Blade	SS 304
Shaft (up to Gear Box	SS 304
All fasteners / hardware	SS 304 or better

❖ **SPECIFICATONS FOR CAST IRON OPEN CHANNEL GATES**

General

The construction of cast iron open channel gate shall be strictly in accordance with the specifications mentioned hereunder. The open channel gate shall be capable of performing the isolation duties in water/waste water treatment plant for those applications where the height of water is at least 300mm less than the height of opening/shutter. They shall be so constructed that there is no undue wear or deterioration during its operative life and so designed that the maintenance is kept to a minimum.

Design

The open channel gate shall comprise of frame suitable for mounting in the parallel side walls of the channel. The frame shall be self-contained type with a yoke on top for mounting of the operating arrangement. The shutter shall move within the frame guides and shall be provided with suitable connecting arrangement to enable connect it to the spindle.

Water sealing on sides and bottom shall be affected by means of non-corroding seating faces secured in groves of frames and remaining in forced contact with corresponding sealing arrangement mounted on shutter. Bottom sealing arrangement shall be flush bottom type to ensure that invert level of channel on either side of gate remains flush with the invert of the gate.

The spindle shall be rising type and provided with stop nut to avoid over closing of gate. The rising spindle shall be provided with transparent scratch proof and UV resistant polycarbonate cover tube to protect the threaded portion from the effect of dust, dirt and rain. The operating arrangement shall be manual or electric as specified elsewhere in the tender specifications. In case of manual operation operating mechanism should be such that the effort required to open/close the gate does not exceed 18kgs with diameter of hand wheel / crank restricted to maximum 750mm. However for all gates of size above 1000mm x 1000mm or above 1 m^2 shutter area shall be gear operated type only.

Materials of Construction

The materials of construction for various components shall be as under.

Gate Frame, Shutter/Door	Cast Iron IS: 210 FG 200
Side Guides	Cast Iron IS: 210 FG 200
Seating faces	Stainless Steel ASTM A 240 Type 304
Rubber Seals	EPDM Rubber to ASTM D 2000
Rubber Seal Retainer Bar	Stainless Steel ASTM A 240 Type 304
Assembly Bolts, Nuts and Fasteners	Stainless Steel ASTM A 276 Type 304
Stem and Connecting Pin	Stainless Steel ASTM A 276 Type 304
Yoke	Mild Steel to IS: 2062 grade A, epoxy painted
Headstock	Cast Iron IS: 210 FG 200
Spindle Cover Tube/Pipe Hood	Polycarbonate

Note: The shutter height of gate shall be at least 300mm above the upstream water level.

❖ SPECIFICATIONS FOR WALL THIMBLE MOUNTED CAST IRON SLUICE GATES

General

The construction of cast iron sluice gates shall be strictly in accordance with the specifications mentioned hereunder. The sluice gates shall be capable of performing the isolation duties in water/ waste water treatment plant and pumping stations for isolation of flow in and out of a closed conduit as well as in those applications where water head is more than the height of shutter/opening. They shall be so constructed that there is no undue wear or deterioration during its operative life and so designed that the maintenance is kept to a minimum.

The Sluice gates shall be wall thimble mounted only except for shallow channels. For shallow channels of up to 3.5 meter depth with water head not exceeding 2.0meter and Gate/Shutter area not exceeding 1.5 m^2 wall mounted gates can be accepted instead of wall thimble.

The gate shall be designed for seating and unseating head of minimum 5m liquid depth or as per design requirement (except for shallow channels/units < 5m total height for which it shall be subject to top of channel/unit and accordingly head shall be as per actual full height).

Design and Construction

The sluice gates shall be manufactured generally as per IS: 13349 (1992). The constructional features and details of components of the required gates are to be as under:

Gate Frame

- The gate frame will be made from cast iron and shall be sufficiently rigid to withstand the designated water head. The gate frame shall either be flat back type or flange back type to suit the designed head and site condition.

- Back flange of the gate aperture frame to be precisely machined flat and drilled to engage with the Cast iron wall thimble mounted on the wall. A rubber gasket will be provided between the wall

thimble and the gate for ease in future dismounting of the gate for repairs/replacement and seal any leakage between the flange of frame and wall thimble.

- The gate frame of these sluice gates shall either be self contained type or non self contained type depending upon site requirement. In case of non self contained gates the frames shall have short length extension guides and shall be without yoke at their top. The length of extension guides in such cases shall be sufficient to engage at least half the overall vertical height of door when the gate is full open and shall be in accordance with the relevant provisions of IS: 13349. In case of self contained gates the frames shall have full length extension guides and shall be provided with a yoke at their top. The length of extension guides in such cases shall be sufficient to engage the overall vertical height of door when the gate is full open position.

Wall Thimble

- The wall thimble will be made from cast iron for placement in the concrete wall. Its front flange will be machined, drilled and tapped to match with the frame flange.

- The cross section of the thimble shall be F shaped and the depth of thimble shall be minimum 300mm long. Gates subjected to high unseating heads shall have thimble cross section shaped E.

- To permit entrapped air to escape as the thimble is being encased in concrete, cast holes of 40mm diameter shall be provided at the bottom of wall thimble in each entrapment zone.

Gate Slide/Shutter/Door

- The gate slide/shutter/door will be made from cast iron and shall be sufficiently ribbed to withstand the designated water head.

- The gate slide/shutter will be provided with integral pocket to house the thrust nut used to connect the stem with the slide.

Seating/Sealing Faces

a. Materials: These should be of Stainless steel or Bronze or as specified.

b. Fitment: The facings shall be attached to flat/rectangular/dovetailed machined faces of gate frame and door, depending upon the applicable water head, and be secured in place using taper screws. The taper screws adopted for facings shall be of same material as that of the seat facings.

c. The front faces of integral extension guides which can come in contact with the sealing faces of door while opening, shall also be fitted with sealing faces of the same material as that of the sealing faces on door. This is required to offer non corroding smooth sliding surfaces to the sealing faces of door/shutter during its vertical travel for opening and enhance the effective life of gate.

d. Finish: The mating seating/sealing faces on the gate frame and door shall be precisely finished for proper contact. They should be so finished that the clearance or gap, if any, between the mating sealing faces, in gate closed position, does not exceed 0.1mm.

Wedging Devices

- The sluice gates shall be provided with individually adjustable wedging devices to ensure forced contact between frame and shutter seat facings, when the gate is in closed position.

- The gates meant for seating head shall be provided only with side wedging devices. Gates meant for unseating head of sizes larger than 600mm, shall be provided with side, top and bottom wedging devices or with side and top wedging devices and flush bottom closing arrangement as required.

- The wedging devices comprise of wedge brackets fitted on gate aperture frame and door. The wedge bracket on frame shall remain in fixed position and those on door shall be adjustable or vice versa. A sort of slot and tannen arrangement shall be provided on base of wedge brackets to prevent any tendency to shift. Provision shall be made to clamp the adjustable brackets firmly in adjusted position.

- The wedging devices shall be made of cast iron. If the wedges/wedge blocks of wedging devices are of cast iron, then these are to be lined with contacting faces of the same material as that of sealing faces attached to the gate frame and door.

Conventional OR Flush Bottom Closing

The sluice gates shall be provided with conventional or flush bottom closure arrangement as required.

Generally as a standard the **gates shall be provided with flush bottom closing only especially for gates mounted on bottom of channel** etc. Only the gates mounted above the floor level and having required clearance below for applications like inlet pipe isolation at elevated level, etc. shall be with conventional bottom closing.

The sluice gates provided with conventional bottom closing arrangement involve corrosion resistant metallic contacting sealing faces at the bottom sill of gate. In such cases, the invert of the gate is required to be kept above the floor of the channel/chamber by at least 150mm to 250mm depending upon the size and type of gate. The contractor should verify whether this clearance is available at the site of installation for fitting a conventional bottom closure gate.

In case of conventional closing gate, if the invert of the gate is kept at the same level as that of the channel/chamber floor, then there remains a slot or a groove at the invert of the gate. Debris, dirt etc. which may settle in this slot and may not allow the gate to close properly and this may give rise to heavy leakages while in operation. With a view to avoid this, in situations where the invert of the gate is to remain at the same level as that of the channel/floor, a flush bottom closing gate instead of conventional bottom closing gate should be provided.

Flush bottom closing shall involve a flexible rubber seal at the bottom of the gate, mounted either on the shutter or on the frame, ensuring that the sealing face remains flush with the floor. The cast iron bar fitted at the bottom of the frame is required to be embedded in the channel/chamber floor and for this a cut out/recess of ample dimensions is required to be provided beneath the waterway opening along the gate invert, while constructing the floor. The dimensions of this cut out shall be provided depending upon the feasibility to do so as per actual site conditions.

This cut out/recess is to be later on filled up with removable asphalt or loose concrete mixed with sand dust or vermiculate after putting the gate in position so that it is possible to break open this second stage grout for removal of the gate in future.

The rubber seal employed shall be made of EPDM or Neoprene rubber and the rubber seal retainer bar as well as the fasteners for fitting the rubber seal and the retainer bar are of stainless steel.

Gate Operating Head Stock/Lift Mechanism

- The operating head stocks shall be designed in such a manner as to permit the gate operation by a single person under the specified maximum operating head with an effort of less than 18kgs on the

crank or hand wheel with a radius not exceeding 375mm. Vendor shall provide torque calculations in support of same.

- The headstock may be ungeared or geared type and the geared headstock may be either of single speed or of double speed, as might be necessary to make it convenient for one person to open or close the gate as fast as practicable. Two speed headstocks shall be supplied with gates requiring higher hoisting capacities. In this type of headstock the low speed is meant for crack opening the gate when the effort required to open the gate is maximum and the high speed is meant for further faster opening after the gate is crack opened.

- Geared headstock shall be supplied with easily removable crank handle or handwheel with a radius not exceeding 375mm.

- All the gears of geared headstock shall be kept completely encased in cast iron housing to protect them from damage, dirt, dust, water etc. and other atmospheric effects and thus ensure their smooth operation. Grease nipples shall be provided at proper places for lubricating with grease.

- Headstock meant for mounting on operating platform shall be supplied with a pedestal/floor stand to provide a convenient operating height of approximately 900mm. The pedestal of the headstock shall be provided with a covered window opening to enable cleaning and greasing of stem threads.

Lifting Spindle/Stem

The sluice gates shall be supplied with rising type lifting spindles/stems. The stem shall be provided with acme/square threading, length of threaded portion being about 400mm more than the height of waterway opening. This much extra length is required to allow for a minor variation of approximately 100mm on either side of the specified height of operating platform.

The design of stem will be done as per the provision in IS: 13349.

Stem Block/Connecting Block/Thrust Nut

The rising type stem shall be connected to the door through a stem block/thrust nut housed in a ribbed pocket cast integral with the door. The bottom end of stem shall thread into the stem block and is locked in place by a set screw to prevent the stem from unscrewing. The stem block shall be cast Bronze or Gunmetal.

Safety Stop Nut

The stem shall be provided with a safety stop nut to prevent the chances of over closing of gate which may otherwise damage either the stem or the lifting platform. The stop nut shall be furnished with a set screw for setting it in a fixed position after the gate is installed. Upon installation the safety stop nut should be set in such a way that its bottom remains about 1mm to 2mm away from the top of headstock, in gate closed position.

In case of stainless steel stem, the stop nut shall also be of stainless steel material of the same grade.

Stem/Spindle Couplings

For ease in transportation and handling, maximum length of one piece stem shall be restricted within 5 meter length. Where the stem are required to be furnished in more than one piece, threaded stem couplings shall be furnished to interconnect different sections of the stem. The couplings shall have provision for pinning after inserting in the threaded end of the stem.

In case of stainless-steel stem, the couplings shall also be of stainless steel material of the same grade.

Stem Guide Brackets
Longer stems shall be provided with sufficient number of stem guides to prevent buckling of stem. The stem guide bracket to be provided shall be adjustable center type - wherein a separate stem guide is bolted on to the wall bracket. The stem guide shall be adjustable in the slots on wall bracket in a direction perpendicular to the face of wall. Wall bracket should also offer minor adjustment in the direction parallel to the wall.

The stem guides shall have machine bored split journals to facilitate erection. The journal shall be lined with Brass/Gunmetal bush.

Pipe Hood for Stem
A pipe hood shall be provided on the top of headstock in case of rising spindle/stem gates to cover the spindle threads for protection against damage, dirt, dust, water etc. It shall be made of transparent fracture resistant polycarbonate material. The pipe hood shall have vent holes to prevent condensation.

Gate Opening Indicating Arrangement
Gate opening indicating arrangement shall be provided to indicate the position of the shutter. This shall comprise of scale mounted on the pipehood and an indicator nut mounted on the rising spindle to show the extent of the opening and closing. The minimum scale graduation shall be 25mm.

Materials of Construction
The materials of construction for various components shall be as under.

Gate Frame, Shutter, Thimble	Plain Cast Iron IS: 210 FG 200
Headstock, Wedges, Stem Guides	Plain Cast Iron IS: 210 FG 200 Stem Guide shall be with LTB-2 Lining
Seating/Sealing Faces and Wedge Lining	Stainless Steel ASTM A 240 Type 304
Rubber Seals (If Applicable)	EPDM Rubber to ASTM D 2000
Rubber Seal Retainer Bar (If Applicable)	Plain Cast Iron IS: 210 FG 200/Stainless Steel ASTM A 240 Type 304
Stem, Stem Guide Brackets, Coupling and Stop Nut	Stainless Steel ASTM A 276 Type 304
Assembly Bolts, Nuts and Fasteners	Stainless Steel ASTM A 276 Type 304
Yoke (If Applicable)	Mild Steel to IS: 2062 Grade A, Epoxy Painted
Stem Block	Leaded Tin bronze to IS: 318 Type LTB2
Lift Nut for Manual Ungeared	Leaded Tin bronze to IS: 318 Type LTB2
Pipe Hood for Stem	Transparent Fracture Resistant Polycarbonate Material
Operation	
Lift Nut for Manual Geared/Actuator Operation	As per Gear Box/Actuator Manufacturers' Standards

❖ SPECIFICATIONS FOR SUBMERSIBLE NON-CLOG PUMP (SLUDGE/WASTE WATER)

A. General

The Pump shall be submersible, non-clog, single stage, centrifugal, wear resistance with vertical shaft suitable for permanent installation in wet-pit/sump along with submersible motor and submersible cable of specified length. The pump and motor shall be as one unit together with impeller mounted on extended shaft of motor.

The pump shall be designed to pump waste water or sludge or such fluids having impurities/ solids and operate satisfactorily without detrimental surges, vibration, noise or dynamic imbalance over the required Head-Capacity range. The head-capacity curve of the pump shall have continuously rising head

characteristics with decreasing capacity over the whole performance range of pump. The shut off head of the pump shall be at least 120% of the total head.

The pump shall be selected in such a way so that operating point shall lie on best efficiency point (BEP) or within 15% of BEP flow on either side meeting NPSH requirement. Pump selected with duty point lying on right side of BEP beyond 15% limit shall not be accepted.

The pump shall be selected with intermediate diameter of impeller. The rated impeller diameter shall be at least 10 mm smaller than the maximum impeller diameter possible for the offered pump model. The pump selected for rated performance below minimum impeller diameter shall not be accepted.

Each pump must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system resistance indicated. All pump shall have identical performance.

The pump shall be designed to start with delivery valve semi/fully open to the extent possible.

The pump shall be designed to operate safely at the maximum speed attainable in the reverse direction of rotation due to liquid returning through the pump at times when the power supply to the motor is interrupted and the discharge valve fails to close.

Pumps' rotating parts and assembly shall be statically and dynamically balanced as per ISO 10816/ latest IS standards and shall run smooth without undue noise and vibration.

The auto coupling unit with foundation plate shall be grouted with the RCC foundation with the help of "J" type foundation bolts or as per manufacturer's recommendation/approved size.

The power rating of motor to drive pump shall be suitable to meet maximum requirement of power for the rated impeller throughout its performance range and specific gravity of the liquid.

B. Features of Construction

PUMP

Pump shall be vertical submersible centrifugal, single stage, non-clog suitable for permanent installation in wet-pit/sump. The pump shall have bottom suction and side discharge nozzle. The pump and motor shall be as one unit together with impeller mounted on extended shaft of motor.

The pump having delivery size up to 100mm shall be designed to handle solids of minimum 35-40 mm (for 50mm delivery size), up to 80 mm size (for 100mm delivery size) such that the size of solids to be handled is one pipe size lower than offered pump delivery size. For pumps having delivery size above 100 mm shall be capable of handling solids of minimum 100mm size.

Casing

Pump casing shall be volute type of robust construction and designed for high efficiency. Liquid passages shall be designed to allow free passage and finished smooth. The tongue shall be straight across and filed to a smooth rounded edge. Casing can be provided with wearing rings/wear plates.

Casing shall have facility for removal of clogged material from impeller vanes without dismantling the whole pump.

Impeller

Impeller shall be semi-open or suitable as per manufacturers' design, single suction with smooth and large ways so as to allow free passage to the fluid being pumped. Impeller shall have two/three vanes maximum and be capable to handle solids of specified size. It shall be free from sharp corners and

projections likely to catch and hold rags and stringy materials. Typical sewage has high content of sand, silt and ash, hence the pump design shall be of wear resistant type.

Impeller shall be statically and dynamically balanced preferably at rated speed as per applicable standard so as to avoid vibration. The Impeller shall have back vanes or suitable features to balance axial thrust.

Pump having semi open impeller shall be provided with suitable wear plate fixed in casing with adjusting bolts and nuts.

Suitable mechanisms should be provided to avoid accumulation of grit/silt for enhanced life of mechanical seal.

Impeller Nut
Impeller shall be fixed on rotating shaft with the help of SS 316 impeller screw or cap top type impeller nut with helicoil insert and washer in such a way that impeller doesn't get loose during rotation of pump in either direction.

Shaft Seal/Mechanical Seals
Double mechanical seals shall be provided to protect the motor from ingress of water along the shaft. The preliminary and secondary seals shall be oil-lubricated. The seal faces of the preliminary seal shall be of either tungsten carbide or silicon-carbide faces while the secondary seal can be of carbon versus chrome steel or tungsten carbide. Pumps shall be equipped with an electrical monitoring system for seal failure detection. Use of Lip seals or back to back seals is not allowed. The mechanical seals shall be bi-directional.

Bearings
Pump set shall have double anti friction grease lubricated bearings. The bearings life shall be minimum 40,000 hours of operation. Bearings shall be greased for life i.e. shall not require any re-greasing.

Auto Coupling/Guide Pipe/Lifting Chain
Each pump shall be supplied with pump connector unit in order to connect connector unit to pump support bracket with rubber diaphragm to make leak proof joint and fixing it to the concrete floor of the suction well. The design of the automatic coupling system shall be such that the joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails/wire rope from access level. The pedestal of the automatic coupling system shall be integrally cast with the delivery bend thereby obviating the need of separately bolted CI duck foot bend. It shall be provided with all necessary fixtures like guide wire/guide pipe for guiding the pumps during lifting/lowering.

Each pump shall be provided with stainless steel lifting chain in conforming to relevant standards. The lifting chain shall be provided with dual 'O' rings/shackles in SS 304 at every about 1.5m C-C for intermediate level support of pump and changeover of hoist hook during lowering and lifting

Each pump shall be provided with stainless steel guide pipe/wire rope of required length.
Lifting Hook
To "fish out" a vertical submerged pump set from the wet well (even if a chain has not been attached to the lifting hook prior to the pump set being lowered) the pump shall have a self-centering lifting hook. Its design shall be such that the lifting chain's hook can be engaged to the pump's lifting hook without the need for man to enter the wet well.

INDUCTION MOTOR (Submersible)
The submersible motor shall be induction, squirrel cage and dry type, designed for continuous operation (S1 duty) capable of working satisfactorily in water immersion. Motor shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following electric supply conditions:

Supply voltage	:	415 Volts, 3 Phase, 50 Hz AC supply
Voltage variation	:	± 10%
Frequency variation	:	± 5%
Combined variation of Voltage and Frequency	:	± 10%

The motor shall be generally designed to have performance characteristics like nominal efficiency, locked rotor current etc. in line with IS 12615 (2018) (Efficiency minimum IE2 of IS 12615)

Degree of protection of motor shall be IP 68. The power rating of the motor shall be minimum 110% of power required by the rated impeller on its entire performance range. Further, the minimum power ratings for motors to drive pump should be selected as per table of multiplying safety factor provided for squirrel cage induction motors under electrical specifications and higher of the two ratings shall be provided.

Motor shall be suitable for full voltage & star-delta starting. Motor shall be capable to start and accelerate the load with the applicable method of starting, without exceeding acceptable winding temperature, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage. Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibration shall be within the limit specified in applicable standard unless otherwise specified for the driven equipment. Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standards.

Any joints in the motor insulation such as at coil connection or between slot and end winding section, shall have strength equivalent to that of the slot section of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropical treatment shall be as per the applicable standard.

The stator winding shall be made from high conductivity annealed copper conductor, super enameled insulated winding wires conforming to IS: 8783 (1978) for dry type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS 4800 Part VII (1970) for dry type motors. The corresponding class of insulation shall be class F with temperature rise limited to class B. However, for motors to be operated on VFDs, only class H insulation with temperature rise limited to class F is allowed and motor shall be inverter duty type and to suit for speed variation from 50% to 100% or higher..

As the cable resistance method, due care is taken to account for the correct hot and cold resistance of windings.

If these pump's motors are to be used with Variable Speed Frequency Drives than:

- The motor insulation shall be vacuum varnish impregnated instead of dip varnishing or trickle varnishing with double insulation coating.
- The motor insulation is to be of class H only.
- Current insulated bearings (preferably NDE) required for motor ratings above 200kW.

Terminal chamber shall be of IP 68 type construction to eliminate entry of storm water and dust. The Terminal chamber should be isolated from the motor chamber to prevent entry of liquid/moisture in the motor chamber through the terminal chamber. The terminal shall be the stud type with necessary plain washer, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase to ground clearance.

Protection

Protection against increase in stator winding temperature (15^0 C) shall be provided. Minimum three number thermostats/bimetallic switches in series shall be provided to sense the stator winding temperature.

Sensors are to be provided to detect if leakage of water into the oil housing is above 30% concentration. Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.

The required control unit to process these safety signals and with potential free contact o/p for alarm/ trip shall be provided by pump vendor for suitable interlocking in starter circuit and /or PLC.

Manufacturer shall provide Pump Monitoring Unit (PMU) with each pump set.

Submersible Cable

A watertight cable junction box sealed from the motor shall be provided for the motor power and signaling cables. The cable shall be of sufficient length and shall be brought out of the submerged motor without joint to terminate in junction box/control panel, located in LV panel room/outside the wet well.

Power as well as control cables shall be of dual sheathed EPRS/PVC, armoured type with required numbers. of Copper core, round type and of required size as per design requirement.

The power cable shall be PVC insulated and PVC sheathed, flexible, 3.5/4.0 core round type. The size of the conductor shall be adequate for continuous use under water and air. Cable half/full core as per design to be used for earthing. The size of the conductor and length of cable shall be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

The control cable shall be PVC insulated PVC sheathed, flexible, round type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor, bearing temperature sensor, level sensor (thermostats/bimetallic switches/RTD) of 1.5/2.5 sq. mm, multi strand copper conductor of required number shall be provided or as required as per design. Control cable shall be with minimum 1 number of spare core.

The cable connection to the motor entry should be such that cable fitment should be possible at the site.

Earthing of the motors shall be done in accordance with the relevant provisions of IS: 3043 (1966) for the purpose of earthing these motors, earthing connection may be made to discharge pipe.

Motor Cooling

The motor cooling shall be normally by surrounding water. However jacket cooling with in-built overflow or such suitable design of other method of jacket cooling shall be provide as specified in process data sheet/scope of work or if specified in BOQ.

C. Materials of Construction

The specific requirement shall be considered as under:

Pump Casing	CI IS 210 Gr. FG 260
Casing Wear Ring/Wear Plate	CI IS 210 Gr. FG 260
Suction cover/Oil Chamber/Motor Casing	CI IS 210 Gr. FG 260
Shaft	AISI 410
Shaft Sleeve	AISI 316 (if applicable)
Impeller/Impeller Nut	CF8M
Auto Coupling Unit	CI/WCB
Hardware (Nuts, Bolts, Fasteners, etc.)	SS 304
Motor Jacket (if applicable)	SS 304
Guide Rail Pipe	Heavy Duty minimum 50 mm dia. of SS 304 of suitable length

Lifting Chain	SS 304, Minimum equivalent to sump depth + 3m, with dual 'O' rings/shackles at every about 1.5m center to center.
Bolts, Nuts, Fasteners etc.	SS 304 (All, Wetted and Non-wetted)
Cable length (each run)	As per BOQ or Minimum equivalent to sump depth + 10 m, whichever is higher
Maximum Permissible Solid Size	As specified above in pump specifications

The above MOC is minimum requirement and if process requirement is higher as indicated in process data sheet the stringent MOC to be provided.

- **SPECIFICATIONS FOR SUBMERSIBLE CENTRIFUGAL PUMP (RAW WATER /CLEAR WATER APPLICATION)**

A. General

Pump shall be submersible, vertical shaft, centrifugal, single stage suitable for permanent installation in wet pit/sump/jack-well constructed on the river/dam etc. along with submersible motor and submersible cable of specified length. The pump and motor shall be as one unit together with impeller mounted on extended shaft of motor.

The pump-motor set shall be designed to pump raw/clear water/treated water and operate satisfactorily without detrimental surges, vibration, noise or dynamic imbalance over the required Head-Capacity range. The head-capacity curve of the pump shall have continuously rising head characteristics with decreasing capacity over the whole performance range of pump. The shut off head of the pump shall be at least 120% of the total head.

The pump shall be selected in such a way so that operating point shall lie on best efficiency point (BEP) or within 15% of BEP flow on either side meeting NPSH requirement. Pump selected with duty point lying on right side of BEP beyond 15% limit shall not be accepted.

The pump shall be selected with intermediate diameter of impeller. The rated impeller diameter shall be at least 10 mm smaller than the maximum impeller diameter possible for the offered pump model. The pump selected for rated performance below minimum impeller diameter shall not be accepted.

Each pump must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system resistance indicated. All pump shall have identical performance.

The pump shall be designed to start with delivery valve semi/fully open to the extent possible.

The pump shall be designed to operate safely at the maximum speed attainable in the reverse direction of rotation due to liquid returning through the pump at times when the power supply to the motor is interrupted and the discharge valve fails to close.

Pumps' rotating parts and assembly shall be statically and dynamically balanced as per ISO standards and shall run smooth without undue noise and vibration. The velocity of vibration shall be within the 6.3 mm/second. Noise level shall be limited to 85dBA at a distance of 1.0 m as per relevant and applicable standards.

The sole plates/auto coupling unit with foundation plate shall be grouted with the RCC foundation with the help of "J" type foundation bolts of manufacturers' recommended/approved size.

The power rating of motor to drive pump shall be suitable to meet maximum requirement of power for the rated impeller throughout its performance range and specific gravity of the liquid.

B. Features of Construction

Pump
Pump shall be submersible centrifugal, vertical shaft, single stage suitable for permanent installation in clear water reservoir/sump or in wet pit/sump/jack-well constructed in the river/sump/dam etc. The pump shall have bottom suction and side discharge nozzle. The pump shall be designed to handle silt, clay, pebbles and vegetation those are normally associated with river/surface water.

The SS heavy duty strainer shall be provided at pump suction so as to restrict the entry of oversize solids/floating material in order to run pump set without clogging and interruption. The strainer shall have sufficient suction area and openings throughout its surface to let water in easily. The size of the holes on strainer shall not be more than maximum permissible solid handling size/capacity of pump or lower as per the permissible solid handling capacity of pump and as recommended by pump vendor. The strainer shall be supplied by pump vendor only as per the area of opening and opening requirement to suit the offered pump design (the strainer area of opening shall be minimum 4 times the area of opening of bell mouth/suction).

Casing
Pump casing shall be volute type, of robust construction and designed for high efficiency. Liquid passages shall be designed to allow free passage and finished smooth. The tongue shall be straight across and filed to a smooth rounded edge. Casing can be provided with wearing rings/wear plates.

Impeller
Impeller shall be enclosed or suitable as per manufacturer's design, single suction type with smooth and large ways so as to allow free passage to the fluid being pumped. Impeller shall be designed to handle silt, clay, pebbles & vegetation those are trapped with raw water of river. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials.

Impeller shall be statically and dynamically balanced at rated speed as per applicable standard so as to avoid vibration. The Impeller shall have back vanes or suitable design features to balance axial thrust.

Impeller Nut
Impeller shall be fixed on rotating shaft with the help of SS 316 impeller screw or cap top type impeller nut with helicoil insert and washer in such a way that impeller doesn't get loose during rotation of pump in either direction.

Shaft Seal/Mechanical Seals
Double mechanical seals shall be provided to protect the motor from ingress of water along the shaft. The preliminary and secondary seals shall be oil-lubricated. The seal faces of the preliminary seal shall be of either tungsten carbide or silicon-carbide faces while the secondary seal can be of carbon versus chrome steel or tungsten carbide. Pumps shall be equipped with an electrical monitoring system for seal failure detection. Use of Lip seals or back to back seals is not allowed. The mechanical seals shall be bi-directional.

Bearings
Pump set shall have double anti friction grease lubricated bearings. The bearings life shall be minimum 40,000 hours of operation. Bearings shall be greased for life i.e. shall not require any re-greasing. Bearings shall be of SKF/FAG make only.

Auto Coupling/Guide Pipe/Lifting Chain

Each pump shall be supplied with pump connector unit in order to connect connector unit to pump support bracket with rubber diaphragm to make leak proof joint and fixing it to the concrete floor of the suction well. The design of the automatic coupling system shall be such that the joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails/wire rope from access level. The pedestal of the automatic coupling system shall be integrally cast with the delivery bend thereby obviating the need of separately bolted CI duck foot bend. It shall be provided with all necessary fixtures like guide wire/guide pipe for guiding the pumps during lifting/lowering.

Each pump shall be provided with a stainless steel lifting chain in conforming to relevant standards. The lifting chain shall be provided with dual 'O' rings/shackles in SS-304 at every about 1.5m C-C for intermediate level support of pump and changeover of hoist hook during lowering and lifting

Each pump shall be provided with a stainless steel guide pipe/wire rope of required length.

Lifting Hook
To "fish out" a vertical submerged pump set from the wet well (even if a chain has not been attached to the lifting hook prior to the pump set being lowered) the pump shall have a self-centering lifting hook. Its design shall be such that the lifting chain's hook can be engaged to the pump's lifting hook without the need for man to enter the wet well.

Induction Motor (Submersible)
The submersible motor shall be induction, squirrel cage and dry type, designed for continuous operation (S1 duty) capable of working satisfactorily in water immersion. Motor shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following electric supply conditions:

Supply voltage	:	415 Volts, 3 Phase, 50 Hz AC supply
Voltage variation	:	± 10%
Frequency variation	:	± 5%
Combined variation of Voltage & Frequency	:	±10%

The motor shall be generally designed to have performance characteristics like nominal efficiency, locked rotor current, etc. in line with IS: 12615 (2018) (Efficiency minimum IE2 of IS: 12615)

Degree of protection of motor shall be IP 68. The power rating of the motor shall be minimum 110% of power required by the rated impeller on its entire performance range. Further, the minimum power ratings for motors to drive pump should be selected as per table of safety factor provided for Squirrel cage induction motors under electrical specifications and higher of the two ratings shall be provided.

Motor shall be suitable for full voltage & star-delta starting. Motor shall be capable of start and accelerate the load with the applicable method of starting, without exceeding acceptable winding temperature, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage. Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibration shall be within the limit specified in applicable standard unless otherwise specified for the driven equipment. Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standards.

Any joints in the motor insulation such as at coil connection or between slot and end winding section, shall have strength equivalent to that of the slot section of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropical treatment shall be as per the applicable standard.

The stator winding shall be made from high conductivity annealed copper conductor, super enameled insulated winding wires conforming to IS: 8783 (1978) for dry type motors. The stator winding shall be

of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 Part-VII (1970) for dry type motors. The corresponding class of insulation shall be class F with temperature rise limited to class B. However, however for motors to be operated on VFD, only class H insulation with temperature rise limited to class F is allowed and motor shall be inverter duty type and to suit for speed variation from 50% to 100% or higher.

As the cable resistance method, due care is taken to account for the correct hot and cold resistance of windings.

If these pump's motors are to be used with Variable Speed Frequency drives than,

- The motor insulation shall be vacuum varnish impregnated instead of dip varnishing or trickle varnishing with double insulation coating.
- The motor insulation is to be of class H only.
- Current insulated bearings (preferably NDE) required for motor ratings above 200kW.

Terminal chamber shall be of IP 68 type construction to eliminate entry of storm water and dust. The Terminal chamber should be isolated from the motor chamber to prevent entry of liquid/moisture in the motor chamber through the terminal chamber. The terminal shall be the stud type with necessary plain washer, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase to ground clearance.

Protection

Protection against increase in stator winding temperature (15 ^{0}C) shall be provided. Minimum three number thermostats/bimetallic switches in series shall be provided to sense the stator winding temperature.

Sensors are to be provided to detect if leakage of water into the oil housing is above 30% concentration. Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.

The required control unit to process these safety signals and with potential free contact o/p for alarm/ trip shall be provided by pump vendor for suitable interlocking in starter circuit and/or PLC.

Manufacturer shall provide Pump Monitoring Unit (PMU) with each pump set.

Submersible Cable

A watertight cable junction box sealed from the motor shall be provided for the motor power and signaling cables. The cable shall be of sufficient length and shall be brought out of the submerged motor without joint to terminate in junction box/control panel, located in LV panel room/outside the wet well.

Power as well as control cables shall be of dual sheathed EPRS/PVC armuored type with required numbers of Copper core, round type and of required size as per design requirement.

The power cable shall be PVC insulated and PVC sheathed, flexible, 3.5/4.0 core round type. The size of the conductor shall be adequate for continuous use under water and air. Cable half/full core as per design to be used for earthing. The size of the conductor and length of cable shall be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

The control cable shall be PVC insulated PVC sheathed, flexible, round type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor, bearing temperature sensor, level sensor (thermostats/bimetallic switches/RTD) of 1.5/2.5 sq.mm, multi strand copper conductor of required number shall be provided or as required as per design. Control cable shall be with minimum 1 number of spare core.

The cable connection to the motor entry should be such that cable fitment should be possible at the site.

Earthing of the motors shall be done in accordance with the relevant provisions of IS: 3043 (1966) for the purpose of earthing these motors, earthing connection may be made to discharge pipe.

Motor Cooling
The motor cooling shall be normally by surrounding water. However jacket cooling with in-built overflow or such suitable design of other method of jacket cooling shall be provide as specified in process data sheet/scope of work or if specified in BOQ.

C. Materials of Construction

The specific requirement shall be considered as under.

Pump Casing	CI IS 210 Gr. FG 260
Casing Wear Ring	CF8M/Bronze, IS 318 Gr. LTB 2
Suction Cover/Oil Chamber/Motor Casing	CI IS 210 Gr. FG 260
Shaft	AISI 410
Shaft sleeve	AISI 316 (if applicable)
Impeller/Impeller Nut	CF8M/Bronze IS 318 Gr. LTB 2
Auto Coupling Unit	CI/WCB
Motor Jacket (if applicable)	SS 304
Guide rail pipe	Heavy duty minimum 50mm dia. of SS 304 of suitable length
Lifting Chain	SS 304, Minimum equivalent to sump depth + 3 m with dual 'O' rings/shackles at every about 1.5 m C-C.
Suction Strainer	SS 304
Bolts, Nuts, Fasteners etc.	SS 304 (All, Wetted & Non-wetted)
Cable length (each run)	Minimum equivalent to sump depth + 10 m

The above MOC is minimum requirement and if process requirement is higher as indicated in process data sheet the stringent MOC to be provided.

IMPORTANT NOTE: For pumps to be installed / mounted in existing tank / reservoir, auto coupling, CI duck foot ben, guide pipe and such items not required / applicable for horizontal installation will not be included and in such cases the pump shall be provided with M.S.E.P. Horizontal Stand shall be supplied by the pump vendor, M.S.E.P. Horizontal Stand shall be suitable to withstand vibrations by Pump set

❖ SPECIFICATIONS FOR HORIZONTAL MONO SUBMERSIBLE PUMP SET

The single stage horizontal submersible pump suitable for handling clear cold water commonly erected in open wells/sumps/wet pits shall be sturdy in construction ensuring basic hydraulic, electrical and mechanical performance needs conforming to technical requirements as stipulated in governing standards. Pumps shall conform to latest editions (including amendments and revisions) of IS: 14220 (2018).

The duty point of the pump set shall be located at the optimum efficiency point of the pump rating curves and there should not be steep fall in efficiency in the operating range. The verification of the pump sets performance will be as per relevant latest IS at rated three phase voltage. The pump with lesser number of

stages will be preferred. RPM of pump set shall be 2900. Motor shall be working on three phase 415 V + 10% to - 15% at 50 ± 3% Hz AC supply.

The pump shall have efficiency deviation/drop within (-) 5 digits/points from efficiency at duty point, in pump operating head range from +10% to -25%.

Minimum motor horse power rating, cable size, starting system, minimum overall efficiency and delivery size shall have to be submitted in data sheet.

Pump

The pump shall confirm to IS: 14220.

Casing should be free from blow holes, slag inclusion and other detrimental defects. Casing should be provided with renewable wearing rings except in radial flow pump set. Casing should be hydraulically tested up to 1.5 times shut off pressure.

The Shut-off Head of the pump shall be 120% of Duty Point.

Impeller

Impeller shall be of closed type ensuring required performance and free of cavitation.

Shaft

The common shaft of pump and motor below the impeller shaft assembly including shaft protection sleeve shall be provided.

Suction Casing with Strainer

The opening of suction casing should be of proper size and shape to minimize, eddy current. In order to check entry of foreign materials strainer/screen shall be of minimum thickness of 0.5 mm.

Entrance velocity of water in the pump should not be more than 3.6 m/sec.

Motor

The motor shall confirm to IS: 9283 (2013). It should be designed for 415 + 10% and – 15% volts, 3 phase, 50 cycles/second AC power supply. It should be totally enclosed squirrel cage induction type water cooled and water lubricated sealed against entry from outside water.

The windings shall be of wet type. The thrust bearing should be of wet type water lubricated and designed to take all untoward load at most unfavorable running conditions. Front and Rear bearing housing and thrust bearing housing should preferably be fixed separate replaceable bolts/studs and (not threaded connections) to the starter to facilitate easy dismantling. Inspection agency will open the motor base and check the thrust bearing and tilting pad type.

Full proof sealing arrangement by sand guard shall be provided in the motor inlet body to prevent open well/sump water impurities like sand, silt from entering the motor bearing stator and rotor should be impregnated with a superior varnish Class B thermal insulation properties by vacuum pressure or epoxy paints on stator when cold rolled stamping used and rotor shall be painted with Polyurethane paint and baked for at least ½ hour under controlled temperature condition and not by manual or gravity flow to remove air pocket so that these are thoroughly filled up by varnish. Motor rotor should be preferably lead-shot blasted. Subsequently, rotor body should be baked repeatedly under controlled conditions to ensure long life of paint and hard finish to the surface to avoid corrosion before powder coating. The rotor shaft shall be provided with sleeves in the bearing portion. The windings should be accessible to facilitate checking and locating any faults without disturbing all the coils and also to enable replacement

of any defective coils. It should be possible to rewind the stator with readymade pre-tested coils. Kelvin bridge/digital resistance meter shall preferably be used for measurement of hot and cold resistance of winding for evaluated temperature rise. Full proof arrangement should be made for stopping the rotating of shifting of stampings inside the stator body due to operation of pump set. Earth leakage current should not be more than 50 mili ampere at rated voltage.

The HP rating of motor should be at least 115% of the maximum pump input over entire range.

The motor should not get overloaded in the range of + 10% and (-) 25% of the specified pump head. The meaning of overload will be as per IS: 14220.

The HP rating of motor shall be selected from the standards ratings.

Following points are to be ensured while design and construction of submersible motor. All rotating parts should be individually balanced on machine for minimum 700 RPM (and vibrations of the assembly during the testing shall not exceed to 80 micron peak to peak).

Brass drain plug is to be provided.

Compensating device is to be provided.

Rotor shall be painted and baked under controlled conditions or powder coated.

Winding shall be easy to assemble.

Winding shall be subjected to 1.5 kV for 30 seconds after 24 hours.

It shall have matching grooves for stopping stamping from rotation and shifting.

The rotating component shall be dynamically balance on machine for minimum 700 RPM.

Stamping treated chemically to recover unwanted substance and impurities.

Rotor shall be lead/sand shot blasted.

Thrust plate lapping is to be done on machine and the limit is 0.3 Micron.

Stator end ring shall be of bronze metal or MS.

Stator shall be re-windable with readymade pretested coils in each type of motor offered.

Method of Starting

Starting method up to 7.5 HP motor shall be DOL Starter and from 8 to 30 HP shall be Star Delta or as specified in BOQ.

Cable

Motor shall be provided with three core flat PVC Copper water proof and flexible cable of 5 meter length in single piece of suitable size with ISI mark (IS: 694). The cross sectional areas should be sufficient so as not to cause voltage drop of more than 2.5% of nominal voltage i.e. 10 volts at 415 volts throughout the length of the cable.

Marking and Name Plate

The method of marking the pumps to be delivered under scope of contract shall ensure that all the information will remain legible even after transportation, storage in open space etc. In general the legible and marking upon the goods shall indicate the following.

1) Manufacturer's Brand Name and/or Trade Mark/Model Embossed/Engraved on pump and motor.
2) Year of manufacturing.
3) Any other important matter that the manufacturer deemed fit to be inscribed.
4) BEE Logo is preferable. Manufacturer can give BEE logo voluntarily.

Typical name plate shall be as under.

1 Name of Manufacturer
2 Model
3 Head @ Nominal Duty Point (Meter)
4 Discharge @ Nominal Duty Point (LPM)
5 Overall Efficiency (%)
6 Motor Rating (kW/HP)
7 Rated Speed (RPM)
8 Maximum Current (Ampere)
9 Rated Voltage with Variation (Volt)
10 Rated Frequency (Hz)
11 Connection
12 Type of Duty (Whether Continuous or Not)
13 Delivery Size (mm)
14 Head Range for Non-Overloading Requirement (meter)
15 Year of Manufacture

Testing

Pumps shall have to be performance tested as per IS: 14220/IS: 11346 and motor will be tested as per IS: 9283 at manufacturers works by the TPI. Routine inspection of pump set shall be carried out by the TPI.

Pumps will be tested with NRV fitted.

The manufacturer has to maintain and produce proper record such as calibration of instrument etc. for verification by inspecting agency.

The leakage current of submersible pump set shall not exceed 50 mili amperes at rated voltage. The firm shall furnish their quality assurance plan to the inspecting agency to review the same to their satisfaction.

The manufacturer shall have to provide material test certificate for impeller/shaft for chemical properties carried out at NABL Accredited Laboratory for verification.

Strip Test

The inspecting agency shall dismantle the pump set precisely to carry out the strip test which shall also include thorough review of the materials used with reference to the relevant tests.

Type Test

The type test certificate for electrical performance of motor shall be as per IS: 9283 with latest amendment from NABL Accredited Laboratory for each HP range/frame size of submersible motor shall invariably be submitted for review and acceptance.

Packing

Pump and motor shall be packed in a suitable wooden/corrugated box acceptable to the Employer

Materials of Construction

Materials of construction shall be as under.

Impeller	:	Bronze Grade LTB 2 IS: 318/SS 410
Pump-Motor Shaft and Shaft Sleeves	:	SS Grade X 12 Cr 12 IS: 6603
Pump Casing, Motor Bearing Housing and Base	:	CI Grade FG 260 of IS: 210
Bearing Bush	:	Bronze Grade LTB 4 of IS: 318
Studs and Bowl supporting Clamps	:	SS AISI 410
Motor Stator	:	SS 304
Motor Stator and Rotor Lamination	:	Silicon Steel Cold Rolled M 45 (Not more than 0.5mm thick IS 648)
Thrust Plate	:	CI Base with Carbon Plate
Stator Winding Wires	:	PVC Insulated as per IS: 8783
Rotor Conductor Core	:	Electrolytic Grade Copper IS: 613
Strainer	:	SS304 (minimum thickness 0.5 mm)
Sand Guard and Drain Plug	:	Bronze Grade LTB 4 as per IS: 318
Breather Diaphragm (Pressure Sustaining Components)	:	Nitrile Rubber

NOTE: The material components should be as per relevant IS except that shown as above.

❖ SPECIFICATIONS FOR SUBMERSIBLE CENTRIFUGAL NON-CLOG PUMP SET (SERVICE/BOOSTER WATER APPLICATION)

General

The pump shall be horizontally/vertically mounted, single stage submersible centrifugal mono pump set with enclosed/semi open type impeller and close coupled to its fully submersible electric motor designed for performance range of the impeller with required reserve power margin.

The total head capacity characteristic of mono pump set shall be continuously rising towards the shut off with the highest at shut off. It shall be suitable for handling clear/chlorinated water.

The pump shall run smooth without undue noise and vibration.

Features of Construction

The pump casing shall be volute type and impeller shall be as described above cast in one piece. Pump with semi open impeller shall be with wear plate of matching profile. The suction nozzle shall preferably be provided with strainer.

The pump and motor shall be as one unit together with impeller mounted on extended shaft of motor and fixed with the help of SS impeller screw or cap top type impeller nut with helicoil insert and washer in such a way that impeller doesn't get loose during rotation of pump in either direction.

Pump with wet type motor shall be duly filled with cooling media and plugged properly. Pump shall be designed for intermittent and frequent operations.

Each pump shall be provided with delivery reflux and isolating valves, required power cables (and control cable if applicable) and suitable lifting gear for lowering and lifting the pump from the sump in

case of fix installation. Power/Control cables shall be of dual sheathed EPRS/PVC type with required number of Copper core, round type and of required size as per design requirement.

Induction Motor (Submersible)

The submersible motor shall be induction, squirrel cage and dry type, designed for continuous operation (S1 duty) capable of working satisfactorily in water immersion. Motor shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following electric supply conditions:

Supply voltage	:	415 Volts, 3 Phase, 50 Hz AC supply
Voltage variation	:	± 10%
Frequency variation	:	± 5%
Combined variation of Voltage and Frequency	:	± 10%

The motor shall be generally designed to have performance characteristics like nominal efficiency, locked rotor current etc. in line with IS: 12615 (2018) (Efficiency minimum IE2 of IS: 12615)

Degree of protection of motor shall be IP 68. The power rating of the motor shall be minimum 110% of power required by the rated impeller on its entire performance range. Further, the minimum power ratings for motors to drive pump should be selected as per table of multiplying safety factor provided for squirrel cage induction motors under electrical specifications and higher of the two ratings shall be provided.

Motor shall be suitable for full voltage and star-delta starting. Motor shall be capable to start and accelerate the load with the applicable method of starting, without exceeding acceptable winding temperature, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage. Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibration shall be within the limit specified in applicable standard unless otherwise specified for the driven equipment. Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standards.

Any joints in the motor insulation such as at coil connection or between slot and end winding section, shall have strength equivalent to that of the slot section of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropical treatment shall be as per the applicable standard.

The stator winding shall be made from high conductivity annealed copper conductor, super enameled insulated winding wires conforming to IS: 8783 (1978) for dry type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 Part VII (1970) for dry type motors. The corresponding class of insulation shall be class F with temperature rise limited to that of class B.

As the cable resistance method, due care is to be taken to account for the correct hot and cold resistance of windings.

Terminal box shall be of IP 68 type construction to eliminate entry of water and dust. The terminal shall be the stud type with necessary plain washer, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase to ground clearance.

Materials of Construction

Casing/Casing Cover/Wear Plates/Oil Chamber/Motor Housing	CI IS 210 Gr. FG 260

Impeller	CI IS 210 Gr. FG 260
Shaft/Shaft Sleeve	AISI 410
Shaft Sealing	Double Mechanical Seal (as applicable)
Lifting Arrangement	SS 304 chain or wire rope with hook(s) and having minimum length equivalent to sump depth + 3 m.
Cable Length (each run)	Minimum equivalent to sump depth + 10m

The above MOC is minimum requirement and if process requirement is higher as indicated in process data sheet the stringent MOC to be provided.

❖ **SUBMERSIBLE NON-CLOG DE-SILTING/DEWATERING PUMP SET (PORTABLE)**

General
The pump shall be non-clog, vertically-mounted, single stage with semi open/open-impeller type and close coupled to its fully submersible electric motors designed for dewatering.

The total head capacity characteristic of pump shall be continuously rising towards the shutoff with the highest at shut off. It shall be suitable for handling turbid water containing stringy materials. The pump shall be designed to handle solids up to 25 mm dia. size.

The pump shall run smooth without undue noise and vibration.

The power rating of the pump motor shall be minimum 150% more than the power required from zero discharge to zero head.

Features of Construction
The pump casing shall be volute type and impeller shall be non-clog type, cast in one piece. Pump with semi open impeller shall be with wear plate of matching profile. Pump impellers shall be designed to pass solids and shall be capable of pumping solids of up to 25 mm diameter.

The pump and motor shall be as one unit together with impeller mounted on extended shaft of motor and fixed with the help of SS 316 impeller screw or cap top type impeller nut with helicoil insert and washer in such a way that impeller doesn't get loose during rotation of pump in either direction.

Pump shaft stuffing box shall be sealed with double mechanical seal, one between motor and oil chamber and second between oil chamber and pump unit, suitable for sewage/dirty water and shall have minimum 20000 hours life. Pump shall be designed for intermittent and frequent operations.

Pumps shall be supplied with all necessary pipe work to discharge to surface drainage. Pumps in general shall be without guide pipe and duck foot bend but with required CI/GI stool/support arrangement to place the pump in location in bottom of sump.

Portable De-silting pump shall be supplied along with starter comprising of MCCB as isolator and required thermal over load relay, contactor etc. (Vendor can also consider to provide MPCB) as per type 2 co-ordination. Starter panel shall be installed near the pump. Starter panel shall be suitable for manual operation through panel mounted on/off push buttons and provided with on, off and trip indications and with local panel mounted digital type ammeter and voltmeter. Vendor to refer specification for LT panel for other general requirement for panel and for make of switchgear as specified under electrical specifications/tender specifications. The pump shall be provided with built-in low level switch to trip the pump in case of inadequate water level and the same shall be interlocked with starter panel supplied with pump.

Induction Motor (Submersible)

The submersible motor shall be induction, squirrel cage and dry type, designed for continuous operation (S1 duty) capable of working satisfactorily in water immersion. Motor shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following electric supply conditions:

Supply voltage	:	415 Volts, 3 Phase, 50 Hz AC supply
Voltage variation	:	± 10%
Frequency variation	:	± 5%
Combined variation of Voltage & Frequency	:	± 10%

The motor shall be generally designed to have performance characteristics like nominal efficiency, locked rotor current etc. in line with IS: 12615 (2018) (Efficiency minimum IE2 of IS: 12615)

Degree of protection of motor shall be IP 68. The power rating of the motor shall be minimum 110% of power required by the rated impeller on its entire performance range. Further, the minimum power ratings for motors to drive pump should be selected as per table of multiplying safety factor provided for squirrel cage induction motors under electrical specifications and higher of the two ratings shall be provided.

Motor shall be suitable for full voltage and star-delta starting. Motor shall be capable to start and accelerate the load with the applicable method of starting, without exceeding acceptable winding temperature, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage. Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibration shall be within the limit specified in applicable standard unless otherwise specified for the driven equipment. Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standards.

Any joints in the motor insulation such as at coil connection or between slot and end winding section, shall have strength equivalent to that of the slot section of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropical treatment shall be as per the applicable standard.

The stator winding shall be made from high conductivity annealed copper conductor, super enameled insulated winding wires conforming to IS: 8783 (1978) for dry type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 Part-VII (1970) for dry type motors. The corresponding class of insulation shall be class F with temperature rise limited to that of class B.

As the cable resistance method, due care is to be taken to account for the correct hot and cold resistance of windings.

Terminal box shall be of IP 68 type construction to eliminate entry of water and dust. The terminal shall be the stud type with necessary plain washer, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase to ground clearance.

Materials of Construction

Casing/Casing Cover/Wear Plates/Oil Chamber/Motor Housing	CI IS 210 Gr. FG 260
Impeller	CI IS 210 Gr. FG 260
Shaft/Shaft Sleeve	AISI 410

Shaft Sealing	Double Mechanical Seal
Lifting Arrangement	SS 304 chain or wire rope with hook/s and having minimum length equivalent to sump depth + 3 m.
Cable length (each run)	Minimum equivalent to sump depth + 10m
Hose pipe	PVC or suitable with required clamps in SS, Minimum equivalent to sump depth + 25m length

❖ **SUBMERSIBLE DRAIN/DEWATERING PUMPS (For Dry Well Installation and Such Applications)**

General

The pump shall be non-clog, vertically-mounted, single stage with semi open/open impeller type and close coupled to its fully submersible electric motors designed for dewatering.

The total head capacity characteristic of pump shall be continuously rising towards the shutoff with the highest at shut off. It shall be suitable for handling turbid water containing stringy materials. The pump shall be designed to handle solids up to 25 mm dia. size.

The pump shall run smooth without undue noise and vibration.

The power rating of the pump motor shall be minimum 150% more than the power required from zero discharge to zero head.

Features of Construction

The pump casing shall be volute type and impeller shall be non-clog type, cast in one piece. Pump with semi open impeller shall be with wear plate of matching profile. Pump impellers shall be designed to pass solids and shall be capable of pumping solids of up to 25 mm diameter.

The pump and motor shall be as one unit together with impeller mounted on extended shaft of motor and fixed with the help of SS 316 impeller screw or cap top type impeller nut with helicoil insert and washer in such a way that impeller doesn't get loose during rotation of pump in either direction.

Pump shaft/stuffing box shall be sealed with double mechanical seal, one between motor and oil chamber and second between oil chamber and pump unit, suitable for sewage and shall have minimum 20000 hours life. Pump shall be designed for intermittent and frequent operations.

Pumps shall be supplied with all necessary pipe work to discharge to nearby surface drainage/sump as required. Each pump shall be provided with delivery reflux and isolating valves, and suitable lifting gear for lowering and lifting the pump from the sump in case of fixed installation/when installed in dry well.

Pumps in general shall be without guide pipe, and duck foot bend but with required CI/GI stool/ support arrangement to place the pump in location in dewatering pit of dry well or in bottom of sump as required.

Pump if required to be supplied with starter panel, the starter panel shall be comprising of MCCB as isolator and required thermal over load relay and contactor etc. (Vendor can also consider to provide MPCB) as per type 2 co-ordination. Starter panel shall be installed near the pump. Starter panel shall be provided with A/M and L/R selector switches as required such that when L/R selector switch placed in local mode it shall be possible for manual operation through panel mounted on/off push buttons when A/M selector switch placed in manual as well as in auto mode through in-built level switches or other applicable method when A/M selector switch placed in AUTO mode and shall be possible to operate from remote location through PLC/SCADA when L/R selector switch placed in Remote Mode. Potential control circuit shall be suitable for on/off operation from remote and shall also provide potential free

contacts for remote monitoring of pump status viz. on/off status, A/M & L/R selector switch status, trip status etc. feedback signals to PLC and on/off command. Panel shall be provided with required on, off and trip indications and local panel mounted digital type ammeter and voltmeter. Vendor to refer specification for LT panel for other general requirement for panel and for make of switchgear as specified under electrical specifications/tender specifications.

The dewatering pump shall operate in auto mode through in-built low and high level float switch to be supplied with pump and suitably interlocked with control circuit for turning ON the pump at high level and turning OFF the pump at low level. High-High level float switch shall also be provided along with pump for necessary alarm at control panel. Necessary junction box and cables in required length from level switch up to junction box and from junction box to starter panel & control panel, as applicable, shall be included in the scope of supply of this item.

Induction Motor (Submersible)

The submersible motor shall be induction, squirrel cage and dry type, designed for continuous operation (S1 duty) capable of working satisfactorily in water immersion. Motor shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following electric supply conditions:

Supply voltage	:	415 Volts, 3 Phase, 50 Hz AC supply
Voltage variation	:	± 10%
Frequency variation	:	± 5%
Combined variation of Voltage & Frequency	:	± 10%

The motor shall be generally designed to have performance characteristics like nominal efficiency, locked rotor current etc. in line with IS: 12615 (2018). (Efficiency minimum IE2 of IS: 12615)

Degree of protection of motor shall be IP 68. The power rating of the motor shall be minimum 110% of power required by the rated impeller on its entire performance range. Further, the minimum power ratings for motors to drive pump should be selected as per table of multiplying safety factor provided for squirrel cage induction motors under electrical specifications and higher of the two ratings shall be provided.

Motor shall be suitable for full voltage and star-delta starting. Motor shall be capable of starting and accelerate the load with the applicable method of starting, without exceeding acceptable winding temperature, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage. Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibration shall be within the limit specified in applicable standard unless otherwise specified for the driven equipment. Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standards.

Any joints in the motor insulation such as at coil connection or between slot and end winding section, shall have strength equivalent to that of the slot section of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropical treatment shall be as per the applicable standard.

The stator winding shall be made from high conductivity annealed copper conductor, super enameled insulated winding wires conforming to IS: 8783 (1978) for dry type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 Part-VII (1970) for dry type motors. The corresponding class of insulation shall be class F with temperature rise limited to that of class B.

As the cable resistance method, due care is to be taken to account for the correct hot and cold resistance of windings.

Terminal box shall be of IP 68 type construction to eliminate entry of water and dust. The terminal shall be the stud type with necessary plain washer, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase to ground clearance.

Materials of Construction

Casing/Casing Cover/Wear Plates/Oil Chamber/Motor Housing	CI IS 210 Gr FG 260
Impeller	CI IS 210 Gr. FG 260
Shaft/Shaft Sleeve	AISI 410
Shaft Sealing	Double Mechanical Seal
Cable Length (each run)	Minimum 10m
Lifting Arrangement	SS 304 chain or wire rope with lifting hook, minimum 5m length if the pump weight exceed 40 Kg

Alternately bidder can also provide non clog, self-priming, horizontal mono block or direct coupled, single stage type pump suitable for dewatering instead of submersible type with majority features and MOC as above.

❖ SPECIFICATION FOR HORIZONTAL SPLIT CASE CENTRIFUGAL PUMP

A. General

The pump shall be centrifugal, horizontal shaft, horizontal (axially) split case type designed and manufactured for pumping liquid like raw/clear/treated water. Pump shall be directly coupled to motor through coupling, mounted on common base plate with foundation bolts and all other required accessories.

The HSCF pump shall comply with all currently applicable statutes, regulations and safety codes and performance shall conform to IS: 5120, IS: 6595 Part I, IS: 11346 and IS: 9137 or their latest revision/edition.

The pump shall be designed to operate satisfactorily without detrimental surges, vibration, noise or dynamic imbalance over the required Head-Capacity range. The head-capacity curve of the pump shall have continuously rising head characteristics with decreasing capacity over the entire performance range of pump. Pump with drooping curves are not acceptable. The shut off head of the pump shall be minimum 110% of the total rated head but not more than 125% of the total rated head.

The pump shall be selected in such a way so that operating point shall lie on best efficiency point (BEP) or within 10% of BEP flow on either side meeting NPSH requirement. Pump selected with duty point lying on right side of BEP beyond 15% limit shall not be accepted.

The pump shall be selected with intermediate diameter of impeller. The rated impeller diameter shall be at least 10mm smaller than the maximum impeller diameter possible for the offered pump model. The pump selected for rated performance below minimum impeller diameter shall not be accepted.

The manufacturer shall ensure while selecting pump that required Net Positive Suction Head (NPSHr) is always less than available NPSH (NPSHa) to ensure pump's operation without cavitation under the worst operating conditions. The required NPSH at duty point and throughout the range shall be at least 0.75m and 0.5m less than the available NPSH respectively at the lowest water level in the sump. However, the

NHPSR of the offered pump model shall be as per the design requirement/as per the conditions indicated in tender drawings. However it shall not be more than 7.0m in (in case of flooded suction conditions).

Each pump must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system resistance indicated. All pump shall have identical performance.

The pump shall be designed to start with delivery valve semi/fully open to the extent possible.

The unit shall be designed to operate safely at the maximum speed attainable in the reverse direction of rotation due to water returning through the pump at times when the power supply to the motor is interrupted and the discharge valve fails to close.

Pump's rotating assembly shall be statically and dynamically balanced as per ISO standards and shall run smooth without undue noise and vibration. The velocity of vibration shall be within the 4.5 mm/sec. Noise level shall be limited to 85 dBA at a distance of 1.0m or as per applicable standards and HIS guidelines.

The power rating of motor to drive pump shall be suitable to meet maximum requirement of power for the rated impeller throughout its performance range.

B. Features of Construction

Pump

Pump shall be horizontal centrifugal, single/double stage, horizontal split case type suitable for dry pit installation with wearing rings. The pump shall have side suction and side discharge nozzle located in lower part of delivery casing.

The SS heavy duty strainer shall be provided at pump suction so as to restrict the entry of oversized solids/floating material in order to run pump set without clogging and interruption. The strainer shall have sufficient suction area and openings throughout its surface to let the water in easily. The size of the holes on strainer shall not be more than maximum permissible solid handling size/capacity of pump or lower as per the permissible solid handling capacity of pump and as recommended by pump vendor. The strainer shall be supplied by pump vendor only (or supplied by contractor as per the drawings of strainer provided by pump vendor) as per the area of opening and opening requirement to suit the offered pump design (the strainer opening area shall not be less than 4 times the area of opening of bell mouth/suction).

Casing

Pump casing shall be single/double suction of robust construction. Liquid passages shall be designed to allow free passage and finished smooth. The tongue shall be straight across and filed to a smooth rounded edge. Casing shall be provided with wearing rings. Casing drain connection with collard plug shall be provided at lowest part of casing. Tapping shall be provided at side center of suction and discharge nozzles for pressure gauge connection. These tapping shall be plugged by collard plugs.

Impeller

It shall be enclosed, single or double suction type or as per manufacturer's design with smooth and large ways so as to allow free passage to the fluid being pumped. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials. Impeller shall preferably be statically and dynamically balanced at rated speed as per applicable standard so as to avoid vibration.

Shaft Sleeve

Replaceable shaft sleeves shall be provided and shall be securely locked or keyed to the shaft to prevent loosening. Necessary rubber 'O' ring or CAF/Teflon gaskets shall be provided between impeller and shaft sleeve to prevent liquid passage between shaft and sleeve. In no case shaft shall be in contact with liquid.

Shaft Sealing Arrangement

1) Stuffing Box
Pump shall be provided with stuffing box arrangement as mentioned in specific requirement for shaft sealing.

Pump when required with gland packed stuffing box; same shall be of such design that they can be repacked without removal of 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. Lantern ring shall be sandwiched between packing and shall be easily removable. Lantern ring shall be of axially split type and shall be sealed with self-liquid being pumped or as recommended by the pump manufacturer. Necessary pipe connections and piping for this shall be provided by pump manufacturer. Gland shall be of split type. Gland bolts and nuts shall be of SS.

Pumps shall be supplied with rubber liquid deflector to prevent liquid entry to bearings, in case of failure of mechanical seal/leakage through stuffing box.
Pumps with rated design/duty head less than and up to 45 meters (maximum), gland packed stuffing box type shaft sealing arrangement is acceptable unless otherwise specified in BOQ / Price Bid.

2) Mechanical Seal
Pumps required with mechanical seals shall be equipped with mechanical seal and sealing systems in accordance with API 682 (third edition 2004)/DIN 24960 standards and ISO 21049 including pump and seal interface dimensions. Seal face material shall be Silicon Carbide Vs Silicon Carbide. Mechanical seal shall be cartridge mounted and balanced type. The seal box size shall be sufficient to dissipate the heat generated. Pump seal boxes shall be sized to accommodate mechanical seal system.

Provisions shall be made to center the seal gland and/or chamber with either an inside or outside diameter register fit. The register fit surface shall be concentric to the shaft and shall have a total indicated runout of not more than 125µm (0.005 in). Using the seal gland bolts to center mechanical seal components is not acceptable.

Seal chamber face runout (TIR) shall not exceed 0.5µm/mm (0.0005 in/in) of seal chamber bore. Seal box vent and drain piping with isolation valves manifold to other pump vent/drain connections shall be provided. Provision shall be made to ensure complete venting of the seal chamber.

Mechanical seal shall be designed and selected for the specified application in order to perform the equipment trouble free and working life shall be minimum 15000 hours of operation. Seals shall be covered with SS 304 mechanical seal cover and shall be tightened with SS fasteners as per the specifications.

External fluid piping for cooling, flushing and lubrication of seal faces shall be designed to suit pressure and temperature of fluid handled as recommended by the seal manufacturer. Seal flush medium, pressure, temperature and flow rate shall be specified. In case of pumps for pumping raw, mechanical seals must be supplied with SS 316 cyclone separator arrangement. The flushing pipe shall be stainless steel (SS 316) and cooling water pipes and fittings shall be carbon steel.

Seal must be designed to handle pumping of raw/clear water as the case may be or as per requirements specified in data sheet. For cooling of mechanical seal same raw/clear water will be used. No clear water will be available for seal cooling. For flushing/quenching plan as per API 682 shall be followed. In addition, where pressure reducing valve is required it shall be provided.

Seal glands and seal chambers shall have provision for only those connections required by the seal flush plan.

Pump Manufacturer/Contractor is responsible for arrangement of cooling/flushing by clear water required for bearing pedestal cooling and seal cooling stating required flow and confirming available pressure.

Specified seal and pump connections shall be identified by symbols permanently marked into the component (such as stamped, cast or chemically etched). Symbols shall be in accordance with those specified in ISO 21049/DIN 24960 standards.

Pumps with rated design/duty head more than 45 meters, only mechanical seal type shaft sealing arrangement is acceptable unless otherwise specified in BOQ/Price Bid.

However mechanical seal type arrangement is acceptable for pumps with rated heads for ≤ 45 meters if the contractor chooses or shall be as specified otherwise in BOQ/Price Bid.

Bearings
Pump shall be provided with anti-friction grease lubricated bearings. The entire rotating assembly of pump shall rest between minimum two bearings for smooth operation. Bearings shall be easily accessible for inspection and maintenance.

Coupling
Pump shall be coupled with electric motor mounted on a common base plate using pin bush type coupling of standard / reputed make. Coupling shall be statically and dynamically balanced at rated speed.

Coupling Guard
A stationary coupling guard shall be provided for the coupling conforming to all relevant safety codes and regulations. Coupling guard design shall be such that coupling is covered from both the sides as well apart from top cover. Guard shall be designed for easy installation and removal, complete with necessary support, accessories and SS fasteners.

Base Plate
The pumping unit shall be provided with a common drain rim type base plate with 25mm dia. drain pipe terminated to nearest drain pit/trench. The base plate shall be of sufficient size and rigid construction fabricated from standard steel section conforming to IS: 2062 sufficient to maintain the pump and motor in proper alignment and position.

The minimum height of section shall conform to following table.

Pump with drive rating up to	Minimum Section height
Up to 30 kW	100 mm
37 kW to 55 kW	125 mm
75 kW	150 mm
90 kW and Above	200 mm

Base plate shall invariably be supplied by the pump manufacturer only.
The base plate shall be grouted on the RCC foundation with the help of "J" type foundation bolts of manufacturer's recommended/approved size.

C. Materials of Construction
The materials of construction shall be considered as under.

Pump Casing	: CI IS 210 Gr. FG 260
Casing/Impeller Wear Ring	: CF8M/Bronze IS 318 Gr. LTB 4/SS 304 L
Shaft	: AISI 410
Shaft Sleeve	: AISI 410H or better
Impeller	: CF8M/Bronze IS 318 Gr. LTB 2

Shaft Seal	: Gland Packed (For operating heads ≤ 45 meters) Mechanical Seal (For operating heads > 45 meters)
Lantern Ring	: Bronze IS 318, Gr. LTB
Liquid Deflector	: Natural Rubber
Gland	: CI IS 210 Gr. FG 260
Base Plate (Drain Rim type)	: CI/MS Epoxy Coated
Suction Strainer	: SS 304
Bolts, Nuts, Fasteners etc.	: Wetted and Non-Wetted SS 304

The above MOC is for minimum requirement and if process requirement is higher as indicated in process data sheet, the stringent MOC is to be provided.

❖ SPECIFICATION FOR VERTICAL TURBINE CENTRIFUGAL PUMP

A. General

The Pump shall be single or multi stage, wet pit, centrifugal, vertical shaft, vertical turbine type designed and manufactured to operate without being affected by large water level fluctuations and pumping raw/ potable water with suction strainer, bell mouth, column assembly, discharge elbow, motor stool, thrust bearing, non-reversing device etc. Pump shall be directly coupled to motor through coupling, mounted on motor stool, sole plates with foundation bolts and all other required accessories.

The vertical turbine pump shall comply with all currently applicable statutes, regulations and safety codes and performance shall conform to IS: 1710 and IS: 11346 or their latest revision/edition.

The nominal RPM of pump generally shall be maximum 1450 RPM, where suspended total column length (excluding total length of VT pump) is equivalent or less than 15m and the same shall be maximum 1000 RPM where total suspended length of column exceeds 15m (excluding total length of VT pump) unless specified otherwise in BOQ/Price Bid. Similarly nominal RPM of pump generally shall be maximum 1450 RPM where column size is up to 500mm and the same shall be maximum 1000 RPM where column size is more than 500mm unless specified otherwise in BOQ/Price Bid.

The pump shall be designed to operate satisfactorily without detrimental surges, vibration, noise or dynamic imbalance over the required Head-Capacity range. The head-capacity curve of the pump shall have continuously rising head characteristics with decreasing capacity over the entire performance range of pump. The shut off head of the pump shall be minimum 115% of total rated head and not exceeding 135% of total rated head.

The pump shall be selected in such a way so that operating point shall lie on best efficiency point (BEP) or within 15% of BEP flow on either side meeting minimum submergence requirement.

The pump shall be selected with intermediate diameter of impeller. The rated impeller diameter shall be at least 10mm smaller than the maximum impeller diameter possible for the offered pump model. The pump selected for rated performance below minimum impeller diameter shall not be accepted.

The manufacturer shall ensure while selecting pump that required Net Positive Suction Head (NPSH) is less than available NPSH to ensure pump's operation without cavitation under the worst operating conditions. The required NPSH at duty point and throughout the range shall be at least 1.0m and 0.5m less than the available NPSH respectively at the lowest water level in the sump.

Each pump must be capable of running satisfactorily in parallel with other pumps in the system without throttling and by itself without cavitation or overload under all operating conditions within the system resistance indicated. All pumps shall have identical performance.

The pump shall be designed to start with delivery valve in semi/fully open condition to the extent possible.

The unit shall be designed to operate safely at the maximum speed attainable in the reverse direction of rotation due to water returning through the pump at times when the power supply to the motor is interrupted and the discharge valve fails to close.

Pump's rotating assembly shall be statically and dynamically balanced as per ISO standards and shall run smooth without undue noise and vibration. The velocity of vibration shall be within the 4.5 mm/second. Noise level shall be limited to 85 dBA at a distance of 1.5 m or as per applicable and relevant standards/HIS guidelines.

The power rating of motors to drive pumps shall be suitable to meet maximum requirement of power for the rated impeller throughout its performance range.

Computational fluid dynamics analysis of the sump model study should be made available to determine sump flow condition at the offered pump inlet for unit pump flow exceeding 3000 m^3/hr.

B. Features of Construction

Pump
Pump shall be vertical turbine comprising of complete pump unit assembly, column assembly and discharge head assembly, sole plates, motor stool, thrust bearing housing, etc.

The Pump unit assembly shall consist of suction strainer, bell mouth, impeller(s), impeller/pump shaft, shaft sleeves, bowl assembly comprising of suction covers, bowl(s), pump shaft bearings, wear rings etc. The bowl shall have integral housing to provide support for pump shaft bearings.

The column assembly shall consist of column pipes, bearing spiders to hold line bearings, line bearings, line shafts, couplings, shaft sleeves, shaft enclosing tubes etc. to convey the liquid handled from bowl assembly to shaft assemblies and discharge elbow.

The discharge head assembly shall consist of discharge head with side discharge flange, stuffing box assembly, motor/drive shaft, thrust bearing assembly with bearing cooling system etc.

Bowl
The pump bowl shall be of robust construction and free from blow holes and other detrimental defects. Liquid passages shall be designed to allow free passage and finished smooth. Bowl shall be provided with replaceable wearing rings/suction covers and shall contain bushes to serve as bearings for the impeller shaft.

The SS heavy duty strainer shall be provided at pump suction so as to restrict the entry of oversize solids/ floating material in order to run pump without clogging and interruption. The strainer shall have sufficient suction area and openings throughout its surface to let the water in easily. The size of the holes on strainer shall not be more than maximum permissible solid handling size/capacity of pump or lower as per the permissible solid handling capacity of pump and as recommended by pump vendor. The strainer shall be supplied by pump vendor only as per the area of opening and opening requirement to suit the pump model offered (strainer area of opening shall be minimum 4 times the opening area of bell mouth/ suction).

Impeller
Impeller shall be enclosed/semi open type, single suction type with smooth and large ways so as to allow free passage to the fluid being pumped. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials. Impeller shall be statically and dynamically balanced at rated speed as per applicable standard so as to avoid vibration. Impellers shall be adjustable vertically by means of an adjusting nut in the head assembly.

Impeller shall be securely fastened to the impeller shaft with keys, taper bushings or lock-nuts.

The impeller adjustment shall be such that the impeller runs free in any installed condition despite extension of line shaft (caused by hydraulic down thrust), the weight of shafting and weight of impellers.

The bowl and impeller shall be designed not to generate internal resonance.

Impeller Shaft
The impeller/pump shaft shall be made of high tensile alloy steel. It shall be guided by shaft bearings above and below each impeller. The butting faces of the shaft shall be machined square to the axis and the shaft ends shall be chamfered at the edges.

Line Shaft
The line shaft shall be designed so as to transfer required power and rotate the complete rotating assembly from stand still to rated speed without generating any vibration, noise or shear of shaft.

The critical speed of the shaft shall be at least 30% lower or above the operating speed.

The shaft shall be furnished with interchangeable sections having a nominal length of 1.5m or 2.5m or in between (1.5 to 2.5m) unless specified other in specific requirement/BOQ/Price Bid. The maximum permissible error in the axial alignment of the thread axis with the axis of the shaft shall be 0.05mm in 150mm.

Line shafts shall be connected through threaded or muff couplings designed with a safety factor of 150% of shaft factor and shall have positive locking/tightening during pump operation.

Line Shaft Bearings
Line shaft bearings shall be of "Thordon" type or any composite material like "Feroform", in general, with outer shell of brass or suitable or as specified in specific requirement. Anti-friction bearing shall be of standard type and shall be selected to give 20000 hours continuous operation at rated conditions.

The line shaft bearings shall be housed in bearing spider (in case of self-lubricated pumps) and sandwiched between flanges of two consecutive column pipes. Bearing spiders shall be designed to support and locate the line shaft in the center.

Column Pipe
The standard lengths of column pipe shall be same as of line shaft nominal length, i.e. 1.5m/2.5m maximum or as specified in specific requirement. No part in the column pipe such as the flange outside diameter shall exceed the bowl outside diameter. The column pipe shall be welded Mild Steel pipe or shall be manufactured from tubes confirming to IS 1978 or grade designation E 250 of quality A of IS 2062 with internally and externally epoxy coated. The column pipe shall be double flange ended.

The column pipe size shall be sized generally for velocity range of 2.0 to 2.5 m/sec. The maximum permissible velocity shall be 2.5 m/sec. Further the column losses shall not exceed 0.5m per 10m column length and the rest pump losses (entry, discharge bend etc.) shall not exceed 0.5m.

Shaft Sleeve
Replaceable shaft sleeves shall be provided for each line/transmission shaft bearing and shall be securely locked or keyed to the shaft to prevent loosening.

Stuffing Box
Pump shall be provided with stuffing box arrangement as mentioned in specific requirement for shaft sealing.
Pump when required with gland packed stuffing box, and same shall be of such design that it can be repacked without removal of 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. Necessary pipe

connections and piping for this shall be provided by pump manufacturer. Gland shall be of split type. Gland bolts and nuts shall be of SS.

Thrust Bearings
Pump shall be provided with anti-friction thrust bearings. The entire rotating assembly of pump shall rest on minimum one bearing for smooth operation. Bearings shall be easily accessible for inspection and maintenance. Bearings shall be of approved makes only.

Coupling
The pump shall be coupled with electric motor mounted on a MS/CI motor stool using pin bush type coupling of standard / reputed make. Coupling shall be statically and dynamically balanced at rated speed.

Driver
Driver shall be coupled through flexible pin bush type coupling to the head shaft.

D. Materials of Construction
The specific requirement shall be considered as under.

Bowl/Suction Bell and Cover	:	CI IS 210 Gr. FG 260 with 1.5% to 2% Ni
Pump, Line and Head Shafts	:	AISI 410
Shaft Sleeve	:	AISI 410-H
Shaft Coupling	:	SS 410
Impeller	:	CF8M
Impeller and Casing Wear Rings	:	CF8M
Shaft Seal	:	Gland Packed
Gland Packing	:	Graphited Cotton
Gland	:	CI IS: 210 Gr. FG 260
Length of each Line Shaft and Col. Pipe	:	1.5m to 2.5 m or as specified in BOQ/Price Bid
Column Pipe	:	IS: 1978 or grade E 250 of quality A of IS: 2062 internally and externally epoxy coated
Motor Stool	:	MS Epoxy Coated
Strainer	:	SS 304
Sole plates	:	MS Epoxy Coated
Hardware (Nuts, Bolts, Fasteners etc.)	:	SS 304

The above MOC is for minimum requirement and if process requirement is higher as indicated in process data sheet, the stringent MOC is to be provided.

❖ SPECIFICATIONS FOR DOSING PUMPS - RECIPROCATING TYPE

GENERAL
Dosing pumps shall be mounted in a bund separate from the storage tanks and shall be fully accessible for operating and maintenance purposes without personnel having to enter the bund itself. Where appropriate, the pump bund shall be interconnected with the tank bund at an intermediate level.
The pumps shall be of hydraulically flexed sandwich diaphragm type gland less pumps with hermetically sealed diaphragm allowing complete leak proof operation driven by electric motors. HD type pumps shall be for flow range **> 1100-1200 LPH)** driven by electric motors. However, pumps for up to **1200 LPH flow and pressure up to 4 kg/cm^2** of reciprocating mechanically actuated diaphragm type driven by electric motors can also be accepted.

The pump, motor and drive arrangement shall be mounted on a robust combination base plate. Unless otherwise specified, only one liquid end shall be driven by any motor.

All chemical dosing pumps shall be provided with pulsation dampeners in SS 304 MOC. Metering/Dosing pumps shall have bypass with valves and external or in-built pressure safety valves.

Pumps shall comply with API standard 675, Positive Displacement Pumps - Controlled volume.

The chemical dosing pumps shall be with suitable type of auto stroke adjustment facility for monitoring and controlling the dosing rate through PLC/SCADA system and closed loop control as applicable for optimizing chemical dosing and process control as specified elsewhere for each application. These pumps shall be part of an automatic coagulation control/other process control loop.

PUMP HEAD MATERIALS
Pump heads and diaphragms shall be manufactured from thermoplastic materials viz. PTFE or such suitable for the duty conditions.

PUMP STROKE ADJUSTMENT
Variable stroke mechanisms shall be incorporated in the drive arrangement to allow infinitely variable adjustment of pump output by means of a micrometer, hand wheel or similar mechanical device whilst the pump is running.

Where the pump is part of an automatic coagulation control or other process control loop, the stroke mechanism shall be fitted with a three phase bi-directional motor with torque limiter and automatic stops at both extremes of travel. A position feedback potentiometer shall be provided to facilitate control and remote indication of position. The operational range of stroke adjustment shall not be less than 6:1.

DRIVE ARRANGEMENT
The pump head shall be driven through a totally enclosed speed reduction gearbox with integral reciprocating drive or the adjustable crank or mechanical lost motion type. The gearbox and reciprocating drive shall be oil bath lubricated. The unit shall incorporate filling and drain plugs for oil and an oil level indicator.

DRIVE MOTOR
Drive motors shall be of the three phase cage induction type either for fixed speed or variable speed operation.
Where variable speed operation is specified, the speed turn-down ratio shall be not less than 5:1.

PUMP PERFORMANCE
The performance characteristics of dosing pumps shall be adequate in terms of linearity, accuracy and reproducibility as designed in API standard 675 to achieve the stated plant performance guarantee. The deviation from flow linearity of the pump shall not exceed ±3% of the rated capacity. The steady state accuracy shall not exceed ±1% of the mean delivered flow under fixed system conditions over the entire turndown range. The flow rate repeatability expressed as percent of the rated capacity of the pump shall not exceed ±3% of the rated capacity.

Note: For very small capacity dosing pumps (For flow range of **≤ 25 LPH** and/or **≤ 0.55** kW motor rating) the Bidder can consider to provide skid mounted electronic dosing pumps (solenoid actuated diaphragm pumps) instead of above specified type and of MOC suitable to type of fluid to be handled.

- **SPECIFICATIONS FOR MATERIAL HANDLING SYSTEMS (CRANE / HOIST / CHAIN PULLEY BLOCKS)**

General
Appropriate and suitable material handling arrangements shall be provided for all equipment included in Contractor's scope to transfer the equipment to maintenance area within the building and/or to transfer the equipment outside the building up to ground level for further transportation by the Employer. For this

purpose contactor shall provide monorails and hoist blocks with cross travel facility or cranes with 3D movement (vertical i.e. hoisting motion, longitudinal i.e. long travel motion LT, Cross travel motion CT) where specified.

Codes and Standards

The design, manufacture, inspection and testing of monorails and hoists shall comply with all the currently applicable statutes, regulations and safety codes in the locality where the equipment is to be installed. The monorails and hoists shall conform to the latest edition of the following standards and codes. Other internationally acceptable standards/codes, which ensure equal or higher performance than those specified, are also acceptable. Nothing in this specification shall be construed to relieve the contractor of the required statutory responsibility. In case of any conflict in the standard and this specification, the decision of the Employer shall be final and binding.

IS: 807	:	Design, Erection and Testing of Cranes and Hoists
IS: 3177	:	Electric Overhead Travelling Cranes
IS: 3938	:	Specification for Electric Wire Rope Hoists
IS: 3832	:	Chain Pulley Blocks
IS 2429	:	Round Steel Short Link Hand Chain
IS: 6216	:	Short Link Load Chain Grade 80 Alloy Steel
IS: 2266	:	Steel Wire Ropes
IS: 15560	:	Points Hooks with Shank and Safety Latch
IS: 210	:	Cast Iron Castings

Design Requirements

If not specified elsewhere in specific requirement of tender specifications/BOQ, then generally for the hoists with more than 1.0 metric ton lifting capacity or more than 06 meters lift, motor operated hoist blocks for both long travel and lift shall be provided where rest other hoist blocks shall be of manually operated type for both, longitudinal travel and lift. Minimum 1.5 to 3 meter length of cantilever from edge of building/cladding shall be provided in monorails coming out of the building to lower the equipment to ground level clearing the building sidewalls/cladding and any other facilities beneath the floor up to ground level.

The exact lift/travel and capacity of the hoisting mechanisms and the mode of lifting equipment shall be as per approved GA drawings of building/concerned civil unit.

Clear height shall be maintained when handling one equipment over other, in such case dismantling of any equipment shall not be permitted. The center line of monorail shall not deviate by more than 500 mm from the center of gravity of any equipment that is to be lifted.

Monorails shall be extended outside the building to handle the equipment to ground level. For monorail/hoist routed inside the buildings, suitable machinery well and removable handrail and grating shall be provided on various floors of buildings, as necessary to handle the equipment.

- **ELECRIC OVERHEAD TRAVELLING (EOT) CRANES**

The crane shall be electrically operated, box/standard “I” beam type single/double girder complete with all accessories including down shop conductor, crane rails and fixtures, starter panel, cable up to starter and shall conform to IS: 3177, IS: 807, IS: 3938 and other relevant approved standards. Crane having 10 MT or higher capacity shall be double girder type only and shall be provided as per the relevant IS and other applicable standards.

The crane bridge shall consist of single 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 shall be provided for double girder crane and for single girder crane a center platform and two platforms at drive end shall be provided for ease of

maintenance/access to crane drive. Steel shall be tested for quality conforming to IS: 2062, plates more than 20mm thick shall conform to IS: 2062/BS 4360 or relevant internationally approved standards.

The bridge shall be designed to carry safely the loads specified in IS: 807/BS 2573 or relevant internationally approved standards. All anti-friction 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 skew ness. Bridge and trolley track wheels shall be of forged steel and shall be double flanged type. The wheel diameter and rail sizes shall be suitable for the wheel loads confirming to relevant standards.

The crane rails/square bars shall be of MS polish as per IS: 2062 or better grade of material. Mountings of the wheels shall be designed to facilitate easy removal for maintenance.

Walkways shall be of at least 500 mm clear inside width with 6mm 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 safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 10,000 hours. Electro-magnetic or hydraulic thruster brake shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

Hoist mechanism shall consist of motor, brake, gear box, rope drum and bottom block.

Rope drums shall be grooved and shall be made of seamless pipe as per ASTM 106 Gr. A or B, cast iron of minimum Grade 25 or cast steel, rolled steel of welded construction and in case of welded drum this should be stress relieved and conforming to IS: 3177/BS 466 or relevant internationally approved standards. Rope sheaves are to be made from CI running on drum with provision of adequate guards to prevent the rope from leaving the sheaves.

Hoist rope shall be extra flexible, improved plough galvanised/FMC plough steel rope with well lubricated hemp core and having six strands of 36 wires per strand with minimum ultimate tensile strength of 1.6/1.75 X 106 kN/m^2 of right hand ordinary (RHO) lay construction. The ropes shall have a 6:1 safety factor on the specified safe working load, and shall conform to IS: 2266.

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: 15560 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

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

A SWL plate not less than 150mm in height showing year of manufacture and rated capacity of hoist in figures shall be placed on each side of the crane girder.

The maximum deflection under full load shall not exceed 1/900 of the span.

All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, braking resistors, conductors, insulators, current collectors, pendant push button station, protective devices, operating 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, GI shrouded type. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces. Pendant type push 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' and micro 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' motions of the hook
Long travel motion
Cross travel motion

Crane structures, motor frames 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 unit sets shall be provided with two studs for earthing.

Drive motors shall be suitable for crane duty (S4) application and generally conforming to latest IS: 12615/IEC 600342-1 standards as applicable. Motor shall be designed for frequent reversal, braking, inching and acceleration. Pullout torque shall be 2.15 times the rated torque. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS: 3938/IS: 3177. Limit switches shall be provided for over hoisting and over-lowering and of two extreme ends of trolley travel i.e. cross as well as long travels. Make of Crane Duty (S4) Motors for EOT Crane / electric hoist as per manufacturer standards shall be acceptable.

Drive for hoist drive (up and down motion) shall be provided with VFD. VFD shall be as per vendor selection to suit the application and reliable operation. For this application being intermittent operation, de-rating as specified in tender / electrical specifications, conformal coating, and other specific requirements like provision FA fuse, etc. not required.

Tests and Test Certificates
Overload tests at 125% of the rated load shall be carried out and test certificates shall be furnished for hook, wire rope, brake and complete crane.

Following accessories shall be provided with crane.

a) Mechanical stoppers for long travel and cross travel shall be provided.
b) Pendant push button station shall be located at maximum 1.0meter from operating floor elevation.
c) Earthing terminals shall be provided.
d) Limit switches for over hoist, over lower, over cross travel and over long travel shall be provided.
e) Flexible trailing cable system shall be provided with sufficient number of loops for specified cross travel.

f) The control panel shall be provided. Panel shall be with isolation breaker/switch to receive the power from electrical panel.
g) MS ladder shall be provided by the contractor for maintenance.

Painting
Refer painting requirement / specifications provided separately below.

➢ HAND OPERATED OVERHEAD CRANES

Cranes shall be designed and manufactured in accordance with BS 2573/IS: 3177/IS: 3832 and shall comply with the requirements of BS 466/IS: 3177/IS: 3832 class II medium duty.

The crane details and ancillary equipment provided shall conform with applicable parts of the general requirements specified above for electrically operated over-head cranes, except that the crane shall be manually operated in all motions by conveniently mounted endless chains, arranged for operation by one man.

➢ ELECTRIC CHAIN HOIST AND TRAVELLING TROLLEY

The design, manufacture, inspection and testing of monorail, electric chain hoist and electrically operated traveling trolley shall comply with all the currently applicable statutes, regulations and safety codes in the locality where the equipment is to be installed. Electrically operated chain hoist shall confirm to IS: 6547 (1972) and shall be designed for duty service Class II. Other internationally acceptable standards/codes, which ensure equal or higher performance than those specified, are also acceptable.

IS: 6547 (1972)	:	Electric Chain Hoist
IS: 2429	:	Round Steel Short Hand Link Chain
IS: 6216	:	Short Link Load Chain Grade 80, Alloy Steel
IS: 15560	:	Points Hooks with Shank and Safety Latch
IS: 808	:	Indian Standard Medium Weight Beam
IS: 210	:	Cast Iron Castings

Electrically operated chain pulley hoist shall consist of following major components.
(a) Electrically operated chain hoist, motor with motor cable, hoisting block and hooks complete.
(b) Limit switch to prevent over hoisting and over lowering.
(c) Erection hardware.
(d) Pendent control station suspended from hoist.
(e) Control panel mounted on wall or crane/hoist as applicable.

Load chain shall be Grade 80 alloy steel chain as per IS: 6216 (1982). Chain wheel shall be made from malleable/SG iron cast confirming to IS: 1865, accurately shaped pockets ensuring smooth operation of load chain.

Chain hoist shall be suitable to fix with supporting/monorail girder at fixed location at the top/bottom flange of beam (for fixed installation) and bottom hook shall be so designed that it shall be free to swivel in the loaded conditions without twisting the load chain. Hook shall be forged as per IS: 15560 or its latest amendment.

All running shafts and wheels running on fixed axles/pins shall be fitted with antifriction bearings. Necessary provision shall be made for lubrication of all moving parts and bearings. All exposed bearings shall be suitably sealed or shielded.

Electric chain hoist shall be with limit switch, pendant push button control switch and over load relay.

Drive motors shall be suitable for crane duty (S4) application and generally conforming to latest IS: 12615/IEC 60034-1 standards as applicable. Make of Crane Duty (S4) Motors for EOT Crane / electric hoist as per manufacturer standards shall be acceptable.

Hoist shall be designed into two separate independent units, i.e. motor and hoist for easy maintenance.

The load hook shall be swiveling type forged circular shank section and shall be as per IS: 15560 with antifriction/thrust bearing.

Further, suitable local brake shall be provided as per IS to arrest and sustain loads in all working positions.

The velocity rates, effort on chain required to raise the safe working load and travel and speed shall be within the limit as per IS. Proof load test shall be carried out as per IS: 6547.

Cast iron parts, wherever used, shall be of minimum grade 30, IS: 210.

Trolley for manual/electric cross travel shall be designed to accommodate a wide range of "I" beams and shall be capable of traveling on straight as well as curved monorails with the design being such to maintain uniform distribution of pressure on the flanges.

All gears and pinions shall be case hardened and tempered steel with machine cut teeth in metric modules and shall confirm to relevant Indian standard. Surface hardening of steel is not acceptable.

All running shafts and wheels shall be fitted with ball/roller bearings with a rated life not less than 20 years based on equivalent running time as per IS: 3938.

Monorail 'I' beam shall be medium weight beams (ISMB) as per IS: 808 (1989) (Reaffirmed 1999) for steel beam in case of providing the same.

Clear height of the monorail shall be maintained to handle one equipment over other.

Monorails shall be extended outside the building to handle the equipment to ground level. For monorail/hoist routed inside the buildings, suitable machinery well and removable handrail and grating shall be provided on various floors of buildings as necessary to handle the equipment.

- **MANUALLY OPERATED CHAIN PULLEY BLOCK AND PUSH-PULL GEARED TROLLEY**

General

Hoist shall be designed, manufactured including overload testing with all accessories and shall be as per IS: 3832 and other relevant standards.

Complete unit shall be comprising mainly i) geared trolley with hand chain, ii) hand operated hoist block with hand chain and load chain, iii) gears, load brake and cover parts, iv) load blocks complete with sheaves and lifting hook and v) ratchet and pawl type load brakes.

All chain pulley blocks shall be designed for class II service as per IS: 3832. Materials of construction shall be as per IS: 3832.

Proof load testing must be carried out at 1.5 times the rated load as per relevant IS.

All hoists/chain pulley blocks shall be selected to have minimum headroom and shall be selected to lift heaviest piece of equipment. Further, it shall be possible to handle any equipment without disturbing other equipment.

All gears and bearings shall be lubricated by grease. All lubricating points shall be grouped together in easily accessible position. All parts requiring replacement/inspection/lubrication shall be accessible without need for dismantling of other parts/structures.

All components of hoist of identical capacity and duty shall be interchangeable.

Hoist shall have permanent inscription in English on each side readily recognizable from floor level stating safe working load.

Trolley
Trolley may be push pull geared type and of specified capacity as mentioned in BOQ or as per specific requirements.

It shall be designed to move the load along the "I" beam axis. It shall be rigid and robust in construction with side plates but shall also facilitate easy assembly / disassembly. The material of construction of trolley shall be as per IS 2062.

The steel plates shall extend beyond the trolley wheels on either side so as to act as bumper, protecting the wheels from damage by collision.

Trolley wheels shall be of single flange type in the taper/straight treads and accurately machined and shall be easily removable for repairs/replacement. They shall be compatible with and mounted on roller bearings to minimize frictional load, and parallel to the flanges of the "I" beam. Load shall be evenly distributed on all wheels. Wheel bearings shall be conforming to IS: 2513 or equivalent and shall be of standard make.

Hoist Blocks
The hoist frame shall be made of steel as per IS: 2062 and gear train shall be enclosed in housing. The hoist mechanism shall consist of a grooved rope drum operated through gears. Each end of the rope shall be anchored to the drum in such a way as the anchorage is readily available for maintenance. Each rope shall have two full turns of the drum when the hook is at its lowest position and one spare groove when the hook is at its highest position.

The leading rope taken by the drum should not slope sideways when slack and it should not caught between the gear wheel.

Rope drum, gear box, block etc. should be fabricated out of weld-able quality steel and as per IS: 3177/IS: 4460/IS: 3938.

All gears shall be of high grade heat treated alloy steel conforming to AGMA standards. Gears shall be forged and accurately machined and shall not be of split type.

All pulley blocks shall be provided with automatic mechanical load brakes which will prevent self-lowering of the load and sustain rated load in all working positions. Brakes shall be ratchet and pawl type/shoe and friction disc type and self-actuating at any load position.

The chain pulley block shall be fixed with the trolley with removable type pin(s)/ bolt(s) directly without having upper hook.

Load Chain
The material of construction shall be case hardened alloy steel as per grade 80 of IS: 6216. It shall be of size 8mm to 12mm or higher as required to suit load requirement.

The hand chain wheels shall be of cast steel/SG cast iron/sheet metal, the wheels shall be with flanges and designed to ensure effective operation of hand chain. Further, suitable local brake shall be provided as per IS: 3832 to arrest and sustain loads in all working positions.

Hand Chain
The hand chain shall be of grade 30 of IS: 2429. It shall be properly pitched and polished.

Bottom Block and Load Hook
The bottom block shall be of enclosed type and shall have guard against rope jamming in normal use. It shall have standard forged swivel shank hook fitted on antifriction thrust bearing. It also shall have lock to prevent hook from rotation and locking arrangement to prevent accidental unlocking. Pulley of the bottom block shall be provided with antifriction bearings.

The load hook shall be swiveling type forged circular shank section and shall confirm to IS: 15560. It shall be proof load tested at twice its rated load and with antifriction bearing.

❖ SPECIFICATIONS FOR VARIOUS VALVES & ELECTRIC ACTUATOR

General
Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges to ISO 7005, IS: 6392 or BS 4504. Flange drilling should confirm to IS: 1538.

Valves shall be double flanged type (unless the end connection is permitted otherwise as specified in specifications for each valve below/in process data sheet) and the face shall be parallel to each other and flange face should be at right angles to the valve centerline. Back side of valve flanges shall be machined or spot faced for proper seating of the head and nut.

Generally, valves shall be rated for nominal pressure of PN 1.0 as a minimum or PN 1.6 if required as per process application or as specified in tender specifications/SOQ/BOQ. Further, higher pressure rating valves shall be offered if required as per process application and in MOC as specified in specifications elsewhere for such applications or suitable for such pressure ratings if not specified explicitly. The CI/DI MOC specified are generally for water/sewage/sewage sludge applications. However for industrial effluent and certain chemical applications the valve MOC shall be offered to suit to the process fluid.

Valve buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys.

Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position. For all type of valves/gates (including open channel, thimble mounted, etc.) gear mechanism design and makes shall be as per manufacturer standard

The valve stem, thrust washers, screws, nuts and all other components exposed to water/sewage shall be of a corrosion resistant grade of stainless steel.

Valves shall be free from sharp projections.

For valves with extended spindle/shaft following shall be considered/provided.

- Extended spindle MOC and size to be confirmed by valve manufacturer.
- Head stock/bracket supply shall be in valve vendor scope only. Valve manufacturer also to provide details and MOC of the same in GAD.
- For extended spindle the coupling and guide bracket details shall be provided by manufacturer. Generally it is desired to have two numbers universal couplings (one on top/ below headstock and one in bottom above gear box/valve body). In case of long spindle lengths muff couplings at

about every 3m distance. Shaft guide bracket/support shall be provided if extension spindle is more than 3m long.

A SLUICE/GATE VALVES

Design Requirements and construction Features

Sluice valve shall be non-rising spindle type resilient seated (Manually operated) confirming to IS: 14846/BS 5163 having PN 1.0/PN 1.6 rating free from sharp projections which are likely to catch and hold stringy materials.

Sluice valve shall be rising/non-rising spindle type when operated through electric actuators confirming to IS: 14846/ BS 5163 having PN 1.0/PN 1.6 rating.

For valve size 50mm and above end connection shall be flanged and for sizes below 50mm shall be flanged/threaded type.

Body of the valve shall be designed for 1.5 times the rating of the valve.

Valve flange face shall be parallel to each other and flange face should beat right angle to the valve centerline.

Back side of valve flange shall be machined or spot faced for proper seating of bolt head and nut.

Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.

Valve shall close with clockwise rotation of the hand wheel. The direction of closing shall be marked on the hand wheel.

Valve shall be non-rising or rising spindle type and rated for nominal pressure of PN 1.0/PN 1.6 as per SOQ/BOQ or as specified in tender specification or as per application requirement.

Stem sealing shall be done with NBR wiper ring in case of resilient seated and bonnet gasket shall be of EPDM. Valve shall be powder coated electrostatically internally as well as externally by RAL blue colour.

Accessories shall be provided as under.

1. Valves 300mm and above size shall be provided with repacking arrangement as per IS: 14846.
2. The valves 600mm and above size shall have channel and shoe arrangement as per IS: 14846.
3. The valves 350mm size and above shall have spur/bevel gear arrangement as per IS: 14846.
4. All valves shall have valve's OPEN/CLOSE indicator arrangement as per IS: 14846.

Materials of Construction

a) Body and Bonnet	:	CI IS: 210 FG 200 **OR** DI IS: 1865 Gr. 500/7
b) Wedge	:	CI IS: 210 FG 200 **OR** DI IS: 1865 Gr. 500/7 and core fully Encapsulated with EPDM rubber with integral wedge nut **(For non-rising resilient seated valves)**
c) Spindle Nut	:	Bronze IS: 318 Gr. LTB2
d) Spindle	:	SS BS 970 Gr. 304 S16
e) Seat Rings	:	SS BS 970 Gr. 304 S16
f) Back Seat Bush	:	Bronze IS: 318 Gr. LTB2
g) Shoe and Channel Linings	:	SS to BS 970 Gr. 304 S16

For valve size 50mm and above end connection shall be flanged and for sizes below 50mm shall be flanged/threaded type.

However, valves 15mm to 40mm size shall be generally as per API 6D/API 602 and having Carbon Steel Body (Body: forged carbon steel A105/cast carbon steel Gr WCB, Trim: 13% Cr) in class 150 or higher rating and shall be screwed/flanged ended.

B1 SWING CHECK TYPE REFLUX VALVES (NON RETURN VALVES)

Design Requirements and Construction Features
Non return valve i.e. reflux valve swing check type confirming to IS: 5312 having PN 1.0/PN 1.6 rating free from sharp projections which are likely to catch and hold stringy materials.

For valve size 50mm and above end connection shall be flanged and for sizes below 50mm shall be flanged/threaded type. The valve shall be suitable for mounting on horizontal pipe line.

The internal parts shall be easily accessible for inspection through inspection hole.

Hydraulic passages and doors shall be designed to avoid cavitation.

Valve body shall be designed for 1.5 times the rated pressure.

Valve shall be of swing type or ball type. Ball type valve must house a freely moving ball in such a way that return flow is effectively prevented.

Valve shall be quick closing type with non-slam characteristics in case of swing type. The non-slam characteristics shall be achieved by providing suitable combination of door and hydraulic passages without any external lever/dampening arrangement.

Flow direction shall be clearly embossed on the valve body.

Valve flange face shall be parallel to each other and shall be at right angles to valve centerline. Flange back shall be machined or spot faced for proper seating of bolt head and nut.
Valve shall be rated for nominal pressure of PN 1.0/PN 1.6 as per SOQ/BOQ or as specified in tender specification or as per application requirement.

Accessories shall be provided as under.
1. Valves 300mm and above size shall be provided with by-pass arrangement as per process requirement as per IS: 5312.
2. Valves 300mm and above size shall be provided with drain plugs as per IS: 5312.
3. Valves 450mm size and above shall have support foot as per IS: 5312.

Materials of Construction

a) Body, Cover, Doors and Hinge	:	CI IS: 210 FG 200 **OR** DI IS: 1865 Gr. 500/7
b) Body Ring	:	SS BS 970 Gr. 304 S16
c) Disc Ring	:	SS BS 970 Gr. 304 S16
d) Bearing Bushes	:	Bronze IS: 318 Gr. LTB2/SS BS 970 Gr. 304 S16
e) Gasket	:	Grafoil Filler SS 304 Spiral Wound
f) Ball (if applicable)	:	To Be with EPDM Rubber

However, valves 15mm to 40mm size shall generally as per API 6D/API 602 and having carbon steel body (Body: forged carbon steel A105/cast carbon steel Gr WCB, Trim: 13% Cr) in class 150 or higher rating and shall be screwed/flanged ended

B2 DUAL PLATE CHECK VALVES

General
All double flanged dual plate check valves shall conform to API 594 (1997) and API 598 or its latest amendment for pressure rating PN1.0/PN 1.6/Class 300 as specified in technical data sheet/BOQ. All the parts of the valve shall be designed so as to withstand the test pressure as specified in the standard. Valve shall be free from sharp projections which are likely to get clogged with stringy materials.

The internal dimensions and shape of the body, plates etc. shall ensure that the area for flow passage at any cross section in the valve is not less than the area of the nominal bore of the valve as per manufacturing standard.

The designs of the plates, hinge pin, stop pins etc. shall ensure free swinging of the plates. The spring action shall optimize the equal closing rates of each plate. The dual plates face shall have close face contact with the body seat ring in close position. Valves shall be designed for horizontal and vertical mounting position. The plates shall not vibrate under full or partial flow condition.

Valve shall be quick closing type with non-slam characteristics. The non-slam characteristics shall be achieved by providing suitable combination of plates, springs and hydraulic passages.

B. Features of Construction

Body
Valve body shall be double flanged. The minimum thickness of metal for body shall be as per directives given in the API 594 and shall be maintained throughout any section uniform. The flange to flange dimensions shall be in accordance with manufacturing standard (Tables 2A and 2B).

Body of the valve shall be fitted with removable seat ring securely fixed in machined recesses by proper engineering practice. Rear side of valve flanges shall be machined or spot faced for proper seating of bolt head, washer and nut.

Each check valve shall carry an embossed ARROW to indicate the direction of flow.
Flanges

Valve flange faces shall be parallel to each other and shall be at right angle to the valve centerline. The finish on facing shall comply with MSS SP-6/ASME B 16.5. The flanges and their dimensions of drilling shall be in accordance with the requirements of IS: 1538, Table IV and VI.

Plates and Hinges
Plates and hinges shall be designed so as to withstand satisfactorily the repeated impacts likely to occur during service. Plates shall be securely positioned on body seat face with the assistance of required nos. of spring or other devices. Plate seating face shall be renewable or uniformly deposited weld metal machined and lapped using good manufacturing process so as to provide leak less seating on body face ring.

The spring action shall optimize the equal closing rates of each plate. The plates shall be totally vibration free under full or partial flow condition.

Internal Wetted Parts

Internal wetted parts shall be suitable for the specified service conditions. The term shall include but not be limited to hinges, pins, bolts, bearings and any other part in contact with the fluid medium other than the body, plates, trim, springs and pipe plugs.

Optional Items

1. Valves 150mm and above size shall have lifting eyebolts.
2. Valves 600mm and above size shall have support foot.
3. Valves 600mm and above size shall have bypass arrangement as per process requirement.

Materials of Construction

a) Body	:	CI to IS: 210 FG 200 **OR** DI IS: 1865 Gr. 500/7
b) Disc (Closure Plate)	:	Cast Steel (ASTM A216 Gr. WCB)
b) Seat	:	Nitrile
c) Spring	:	Spring Steel
d) Stop/Hinge Pin and Space Washers	:	SS 304

C KNIFE GATE VALVES

General
Knife edge gate valve shall be manufactured and tested as per MSS SP 81 standards.

Knife gate valves shall be suitable for use in waste water and sewage water containing solids and fibrous wastes etc. These shall be suitable for use at suction and delivery side of pumps as well as in branch lines in a sludge handling application of treatment plant or a pumping station.

The valve should be provided with gate made of stainless steel and the gate should have beveled knife edge at the bottom to cut through and easily enter in the solids settled in the bottom and ensure positive shut-off/closure in sewage environment.

Design
The valve should preferably be bonneted up to 300mm size and bonnet-less for higher sizes. Valves shall be of wafer lug type construction up to 150mm size and full flanged construction for higher sizes. The valve shall be provided with flange drilling to suit ANSI 16.5B 150# with raised face or DIN PN 10 or IS: 1538 (1993) flange connections in between pipelines.

Valve shall be rated for nominal pressure of PN 1.0 as per SOQ/BOQ or as specified in tender specification or as per application requirement. It should be suitable for unidirectional application and should be able to withstand small bi-directional pressure.

The valve body should be cast and provided with replaceable type flexible sealing seals to offer drop tight shut off. The seals should be made of PTFE or EPDM rubber and should be held in place by an easily removable type seal retainer ring.

The valve housing should have integral as cast tapered lugs provided for pushing the gate towards the flexible rubber seal only at the verge of closure with a view to avoid seal wear and achieve drop tight shut off. The surface of the gate coming in contact with the seal should be polished and buffed.

Bonneted type valves shall be provided with O-rings based arrangement to seal the rear opening and reduce the operating torque. Bonnet-less valves shall be provided with sufficient ply of stuffing seals in the inbuilt stuffing box to seal the rear opening. The seals should be of non-asbestos PTFE to reduce the friction and offer higher life. Provision shall be made to enable tighten the stuffing seals. Replacement of

stuffing seals should be possible to be carried out in installed condition of the valve but without there being line pressure.

The spindle should be double start threaded and non-rising type for compact and safe operation. Gate opening indicating arrangement should be provided to find out the extent of gate opening/closing.

Materials of Construction

The following materials of construction shall be offered for the knife gate valves.

Body	: Bonnet less CI FG 260 IS: 210 **OR** DI IS: 1865 Gr. 500/7
Knife Gate	: AISI 304 Gr. ASTM A240
Retainer Ring	: Ductile Iron/Steel Hard Chromed/Stainless Steel Gr. CF 8
Inlet Seal	: PTFE/EPDM
Spindle	: Stainless Steel Gr. ASTM A276 Type 410/303
Spindle Nut	: Bronze IS: 318 GR LT B2
Stuffing Plate	: Cast Steel ASTM A216 Gr. WCB
Stuffing Seal	: Synthetic Fiber (Yarn) impregnated with PTFE
Support Plate/Channel	: Carbon Steel Epoxy Painted/ SS 304

D BUTTERFLY VALVE

Butterfly valve shall be as per IS: 13095/BS 5155. Valve shall be suitable for mounting in any position. Valve shall be rated for nominal pressure as specified above in general requirements.

For valve size 150mm and above end connection shall be flanged and for sizes up to and including 125mm shall be flanged/full lug wafer type.

The valve seat shall be of integrally cast or replaceable design. When the valve is fully closed, the seal shall seat firmly so as to prevent leakage. The seat surfaces shall be machined smooth to provide a long life for the seal.

All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

Valve shall be suitable for throttling purpose.

All valve, spindles and hand wheels shall be positioned to give good access for operational personnel.

Valve of diameter 200mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Butterfly valve where specified shall be electrically operated.

Materials of Construction

Sr. No.	Component	Material
(a)	Body	Cast Iron IS: 210 FG 260 **OR** Ductile Iron IS: 1865 Gr. 500/7

(b)	Body Ring	Stainless Steel BS 970 Gr. 431 S29
(c)	Disc	Ductile Iron IS: 1865 Gr. 500/7
(d)	Shaft	Stainless Steel BS 970 Gr. 431 S29
(e)	Disc Ring	EPDM Rubber
(f)	Bearing	Teflon

E BALL VALVES

General
Ball valve shall be manufactured as per BS EN ISO 17292 and Inspection and testing standard shall be BS EN 12266-1. Valve shall be rated for nominal pressure as specified above in general requirements.

Ball valve shall be supplied with a lever/wrench unless it is gear or electric actuator operated.

Soft-seated ball shall be with antistatic devices.

Soft-sealed BW/SW end ball valves shall have a 100mm long seamless pipe nipple welded to each end of the valve. Nipples are to be welded prior to assembling Teflon seats/seats.

The face-to-face dimensions of all ball valves shall be same as those of gate valves of the corresponding ANSI class up to 200mm NB size. Valves 200mm NB onwards shall be in class 150 where the face-to-face dimensions shall be as per API 6D long pattern.

The ball of ball valve shall not protrude outside the end flanges of valve and shall provide 100% through passage to the flow of liquid.

Ball valve shall be of floating ball/trunnion mounted type as per following.

Class 150	200mm and below	Floating Ball
Class 150	250 mm and above	Trunnion Mounted

Unless otherwise specified, bore of all reduced bore ball valve shall be limited to one size lower than the nominal bore.

Valve Design	:	3 Piece Ball Valve
Type of Bore	:	Full Bore
Materials of Construction		
Body and End Caps	:	ASTMA-351 Gr. CF8M
Ball/Stem	:	AISI- 316
Seat	:	PTFE
End Connection	:	Less than 50mm – Socket Weld End (SW)/Threaded (Screwed End) 50mm and above - Flanged end, 150#
Operation of Valve	:	By Lever/Gear/ Electric Actuator as per SOQ/BOQ

F AIR VALVE WITH ISOLATION SLUICE VALVE

DI temper proof flanged air valve with isolation sluice valve as per IS: 14845 PN 1.6 and IS: 14846 PN 1.6 respectively with SS 304 float, gun metal nozzle, complete hardware, bolts, nuts and washers, gaskets etc. Sluice valve shall meet the requirements as specified in sluice valve specifications here in.

KINETIC AIR VALVE

General

The double acting kinetic air valve shall be manufactured as per IS: 14845 (2000) or its latest amendment suitable for the specified pressure rating. All the parts of the valve shall be designed so as to withstand the test pressure as specified in the standard. Valve shall be free from blow hole, flaw burr or other defects and sharp projections which are likely to get clogged with stringy materials.

The valve shall be capable of releasing air from pipe automatically when the pipe is being filled by liquid without generating high air pressure in pipe and shall remain closed once the pipe is filled to prevent spillage and loss of liquid and maintain rising main's pressure. Similarly, the valve shall be capable to admit air automatically to prevent development of vacuum while the pipe is being emptied.

Features of Construction

Body

Body of the air valve shall be flanged type and shall have high pressure and low pressure chambers to accommodate high pressure and low pressure float respectively. The chambers shall be designed and have proper guide for small orifice float and guide ribs with minimum clearance to large orifice float so as to allow wobble free upward and downward movement of floats in the chamber when required for releasing or admitting air without any obstruction.

Body shall be designed to avoid prematurely closing of the valve by the air whilst being discharged.

The cone angle of the low pressure chamber shall be such that even at critical velocity of air escaping at 344 m/sec the total impact force on the float is less than the suction force on the annular area between the float and cone. Cone angle and the minimum body thickness shall be as specified in IS: 14845 (2000). The low pressure cover shall be designed to withstand full operating thrust in working Conditions.

The seat ring shall be held securely in place under the low pressure cover by a joint support ring to prevent it from sagging when the ball is not sealing the orifice.

High Pressure Orifice

The high pressure orifice shall be so designed that the orifice is effectively sealed in working condition. The orifice shall be of size not less than 2.5mm and tapering to 10mm suitable to release accumulated air within the pipe. The edge of orifice shall be carefully profiled to avoid damage to the float surface. The orifice shall be protected by a Suitable plug of stainless steel.

Flanges

All valve flanges shall be designed to withstand the stresses to which they would be subjected under hydraulic tests. Flanges shall be machined flat and drilled in accordance with IS: 1538, Table 4 and 6. Flange bolt shall be drilled off center.

Floats

The float size shall be as per individual design subject to minimum as specified in IS: 14845 (2000).
The buoyancy of the floats shall ensure effective sealing of large orifice even at low pressure. The float shall be made of seasoned wood or any other material having bearing strength and equivalent specific gravity. The floats shall be externally coated with vulcanite or rubber having required shore hardness as per IS. The floats shall be non-clogging and self-sealing type for trouble free operation.

Low Pressure Seat Ring

Low pressure seat ring shall be of natural or synthetic rubber having required shore hardness. The central orifice shall be profiled for maximum discharge in any given condition of pressure differential between the chamber and atmosphere. The float shall make contact with inner profile of the seat ring and seat ring shall withstand the bearing load under working condition without any deterioration in the quality.

Joint Supporting Ring

Low pressure seat ring shall be held securely in place under low pressure cover by a joint support ring to prevent it from sagging when the float is not sealing the orifice.

Cowl
A cowl shall be temper proof and designed to provide protection to low pressure, large orifice chamber, seat ring and float. It shall be designed to prevent direct ingress of foreign matter inside. There shall be sufficient clearance between the orifice and the cowl to ensure easy passage of air under a given pressure differential.

Materials of Construction

Body and Cover	:	DI IS: 1865 Gr. 500/7
Floats	:	Stainless Steel 304
Gasket	:	EPDM or Nitrile Rubber ASTM D 1418
Cover Bolts and Nuts	:	Carbon Steel

Accessories

1. Isolating DI DF sluice valves manufactured as per IS: 14846 of identical size and rating.

Sluice valve shall meet the requirements as specified in sluice valve specifications here in.

G ELECTRIC ACTUATOR (APPLICABLE FOR VALVES/GATES)

All local controls shall be protected by a lockable cover.

Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gear box shall be oil or grease filled and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.

The valve actuator shall be suitable for ON-OFF type of service and duty shall be S-2 minimum 15 minutes of continuous operation. It should be capable of producing not less than 1½ times the required valve torque i.e. selected actuator rating in Kgm (Nm) shall always be 1.5 times the maximum valve torque in Kgm (Nm).

The operating speed shall be such as to give valve closing and opening within 120 seconds maximum up to 400 mm dia./height of SV/KGV/sluice gates. However for SV/KGV/SG exceeding 400 mm dia. /height shall be maximum within 300 seconds or as per manufacturers' standards subject to fulfilment of actuator torque rating be 1.5 times that of maximum valve torque. Moreover number of turns for valve close to valve open shall be less be preferably less than 200 for sizes up to 400 mm dia. Only in higher sizes the same may be permitted beyond 200 or as per manufacturers' design & standards. The operating speed shown here are for ready reference only. Care must be taken by the valve manufacturer to choose such model of actuator so as to keep the opening & closing time to as low as possible.

The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weather proof housing of IP 68. The motor starter shall be capable of starting the motor under the most severe conditions.

The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication, and shall also be fitted with internal heaters so as to provide protection against damage due to condensation. Heaters shall be suitable for single-phase operation. The heaters shall be switched "ON" when the starters are "OFF" and shall be switched "OFF" when the starters are "ON".

In order to maintain the integrity of the enclosure, setting of the torque levels, position limits and configuration of the indication contacts etc. shall be carried out over an infrared interface (minimum two numbers shall be provided) or with outside push button arrangement or any such suitable arrangement without the removal of any actuator covers.

The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel irrespective of the connection sequence of the power supply.

Each starter shall be equipped as follows as a minimum.

a) AC electric motor.
b) Reduction gear unit (with thrust bearing if required).
c) Torque switch mechanism complete with set of torque switches for "Open" and "Close" position.
d) Limit switch mechanism complete with set of limit switches for "Open" and "Close" position.
e) 2 numbers of auxiliary limit switches to be provided for each direction in the switch mechanism in addition to the torque/limit switch for travel termination (if specified for any application in scope of work/process description & specifications).
f) Hand wheel for manual operation.
g) Hand-auto changeover lever with suitable locking arrangement.
h) Local control switch/push buttons.
i) Forward/Reverse integral starter.
l) 1 Set "Open", "close" and "Stop" buttons as applicable.
m) 1 number Local – Off –Remote switch with padlocking facilities as applicable.
n) Space heater, 220V rated.
o) Position indicator.
p) Position transmitter with 4-20 mA analogue output for valve open/close position if requirement specified elsewhere in tender as per application.

The following relays/potential free contact shall be provided.

- Full open
- Full close
- Torque switch open
- Torque switch closed
- Thermo-switch/thermal overload relay tripped
- Selector switch position local-remote-off
- Single phasing power supply failure.
- Remote position feedback in the form of 4-20 mA (if required/specified).

The actuator shall be suitable for operation in the climate conditions and power supply conditions given in the specification.

AC Electric Motor

Each motor shall be fully tropicalized and suitable for operation in the prevailing climate conditions. They shall also be suitable for operating satisfactorily under variations of electric supply specified.

The motors shall be of appropriate rating for 3 phase, 50 Hz AC electric supply of required speed (RPM) of minimum class 'F' insulated with temperature limited to that off class B, high torque low inertia motors of 15 minutes rating, squirrel cage induction type with 'O' ring seal to provide complete environmental protection during long period of inactivity. The winding shall be impregnated to render them non-hygroscopic and oil resistant. All internal metal parts shall be painted. Motor shall be capable of at least 60 starts per hour. Make of electric motor shall be as per latest governing standards and manufacturers' standards.

Motor Protection
Following motor protection shall be provided.
a) The motor shall be de-energized in the event of a stall when attempting to unseat a jammed valve.
b) Motor temperature shall be sensed by a thermostat to protect against overheating.
c) Single phasing protection.

Motor Controls
The reversing contactor starter and local controls shall be integral for actuator. The starters shall comprise mechanically and electrically interlocked reversing contactor of appropriate rating fed from a 220V control transformer (120V AC for energization of contactors and 24V DC rectifier supply for local control for integral starter is also acceptable). The common connection of the contactor coils at the transformer shall be grounded. HRC type primary and secondary fuses shall be provided.

Local control shall comprise push buttons for open close and stop operations, and a local/remote selector switch lockable in the three positions as below.

Local control only,
Remote control plus local stop only,
Stop locked off - No electrical operation.

Vendor should also make a provision for transmitting the mode selected to control panel and control panel will have corresponding indication lamps.

Integral Starter with Microprocessor Based Programmable Controls

The starter unit shall be with micro controller based control logic. Entire unit along with basic actuator should confirm to IP 68 standard of enclosure.

The actuator shall be field configurable having inbuilt pushbutton and LCD display to configure the features like inching or non-inching (hold on) mode etc. Also LCD display of actuator shall be able to show the operational status and fault information in text format. LCD display shall have minimum 32 characters.

Isolated 24V DC output shall be available for customer's use and for internal use of actuator.

Torque and Turns Limitation

Torque and turns limitation to be adjustable as follows.
- Position setting range – multi-turn: 2.5 to 100,000 turns, with resolution to 15 degree of actuator output.
- Position setting range – direct drive part turn actuators: $90^0 \pm 10^0$, with resolution to 0.1 degree of actuator output.
- Torque setting: 40% to 100% rated torque.

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Measurement of torque shall be from direct measurement of force at the output of the actuator. Methods of determining torque using data derived from the motor such as motor speed, current, flux etc. are not acceptable.

A means for automatic "torque switch bypass" to inhibit torque off during valve unseating and "latching" to prevent torque switch hammer under maintained or repeated control signals shall be provided.

The electrical circuit diagram of the actuator should not vary with valve type remaining identical regardless of whether the valve is to open or close on torque or position limit.

Local Position Indication

The actuator display shall include a dedicated numeric/symbol digital position indicator displaying valve position from fully open to fully close in 1% increments. Valve closed and open positions shall be indicated by symbols showing valve position in relation to the pipe work to ensure that valve status is clearly interpreted. With main power on the display shall be backlit to enhance contrast at low light levels and shall be legible from a distance of at least 6 feet (2 m).

Red, green, and yellow lights corresponding to open, close and intermediate valve positions shall be included on the actuator display when power is switched on. The digital display shall be maintained and updated during hand wheel operation when all power to the actuator is isolated.

In addition, the actuator display shall include a separate text display element with a minimum of 32 characters to display operational, alarm and configuration status. The text display shall be selectable in English. Provision shall be made to upload a different language without removal of any covers or using specialized tools not provided as standard with the actuator.

Monitoring Facilities
Facilities shall be provided for monitoring actuator operation and availability as follows.
Monitor (availability) relay having one change-over contact. The relay being energized from the control transformer will de-energize under any one or more the following conditions.

- Loss of main or customer 24V DC power supply
- Actuator control selected to local or stop
- Motor thermostat tripped
- Actuator internal fault

Where specified, provision shall be made for contacts to provide discreet indication of one or more of the following.
- Remote selected
- Thermostat trip
- Actuator fault

Actuator text display indication of the following status/alarms.
- Closed limit, open limit, moving open, moving closed, stopped.
- Torque trip closing, torque trip opening, stalled.
- ESD active, interlock active.
- Thermostat trip, phase lost, 24V supply lost, Local control failure.
- Configuration error, Position sensor failure, Torque sensor failure.
- Battery low, power loss inhibit.

Integral data logger to record and store the following operational data.

- Opening last/average torque against position
- Closing last/average torque against position
- Opening motor starts against position
- Closing motor starts against position
- Total open/closed operations
- Maximum recorded opening and closing torque values
- Event recorder logging operational conditions (valve, control and actuator)

The data logger shall record relevant time and date information for stored data.

Data logger data is to be accessed via non-intrusive IrDA communication. Sufficient standard intrinsically safe tools shall be provided for downloading data logger and actuator configuration files from the actuators and subsequent uploading to a PC. The actuator manufacturer shall supply PC software to enable data logger files to be viewed and analyzed.

COMMUNICATION CAPABILITY:

The actuator shall be suitable for at least any one of the following control facilities.

- Modbus
- Profibus
- Foundation Fieldbus
- Device Net
- Pakscan

Wiring and Terminals

Internal wiring shall be of grade PVC insulated stranded cable of 650V and of minimum 1.5 mm² copper for control circuits and of minimum 4 mm² for the power circuit. Each wire shall be number identified at each end. The terminals shall be of stud type and they shall also be identified by numbers. Cable entries shall be suitable for suitably sized PVC cables.

Enclosure

Actuators shall be O-ring sealed IP 68. The motor and all other internal electrical elements of the actuator shall be protected from ingress of moisture and dust when the terminal cover is removed for site for cabling, the terminal compartment having the same ingress protection rating as the actuator with the terminal cover removed.
Enclosure must allow for temporary site storage without the need for electrical supply connection.

Position transmitter shall be provided if required to be provided as per process requirement.

Reduction Gear Unit

Reduction gear unit shall be of the totally enclosed oil bath/grease lubricated type. The gear box shall be provided with the first charge of oil lubricants and appropriate filling and drain connections. Gearing shall be adequate to open and close the sluice gates under full indicated maximum operating pressure differential at a speed sufficient to cover the full extent of travel.
The sluice gate operating equipment shall have a hammer-blow device to loosen stuck sluice gate or retrieve jammed sluice gate position.
The gearbox shall have suitable stops to prevent movement of shaft beyond fully open/close position. The gearbox shall also be designed for 15% more torque than maximum sluice gate/valve torque.

❖ SPECIFICAITONS FOR METALLIC EXPANSION BELLOWS

Expansion bellow shall be fabricated in accordance with the EJMA/ASME standard.

The bellows shall be metallic corrugated design of MOC as specified and shall have flanged ends on both sides with liner/internal sleeve. The fatigue life expectancy considered for EB shall be minimum 3000 cycles. The drilling standard of EB flange shall be matched on piping side to ensure proper alignment and bellows is not subjected to torsional forces due to misalignment. It shall be single bellow design and suitable for axial movement of up to total 30mm (20mm axial compression and 10mm axial extension). Further it shall be suitable accommodate angular misalignment of piping for up to minimum 5mm/3 degrees for installation. The overall length of expansion joint for up to 300mm dia. size shall be 250mm, for above 300mm and up to 1000mm it shall be 300mm and for above 1000mm the same shall be 350mm. The austenitic stainless steel shall be welded using the TIG welding method. The shipping bracket of bellows shall be removed only after installation of the bellows at site.

To achieve maximum flexibility coupled with required resistance to pressure, bellows shall be formed with single or multiple walls using a number of concentric cylinders (multi-ply construction) of specified MOC, each longitudinally welded. However for the blower application the bellows shall be of multi-ply construction only.

Generally the expansion joint is provided of single bellow design as a dismantling/disassembly joint in piping near valve or pump or flow meter or such device or equipment for ease of removal and jointing. Tie rods/threaded draw bars attached to expansion joint assembly shall be provided for this application.

In case of bellows used for air piping application/in air blower discharge piping or such application witnessing vibration and temperature variations the expansion joint shall be single bellow with or without limit rods as recommended by manufacturer suitable to absorb axial movement and to suit this requirement. In case of bellows used for diaphragm type dosing pump or such pulsating service the expansion joint shall be single bellow with or without limit rods as recommended by manufacturer suitable to absorb axial movement and to suit this requirement.

The weld end pipe shall be suitable for design pressure (Minimum PN 10 or higher as per design) and for CS/MS weld end pipe shall be with minimum corrosion allowance of 3mm for water/waste water application. However for blower application the bellows shall be designed for a working pressure of minimum 1 Bar or higher as per design and for a temperature of minimum 115^0C or higher as per design and for velocity of minimum 25 m/sec or higher as per design and the liner thickness shall be suitable for the same.

During installation the bellows as a practice shall always to be placed between two fixed points. Thrust block or saddle welded to pipe to make it fixed must be provided on both sides of EB.

The shipping bracket of bellows shall be removed only after installation of the bellows at site.

For blower application generally after the bellow the first support (saddle or suitable) shall be provided at 4D distance and second support 14D distance from bellows to dampen the vibrations.

Materials of Construction

Component Description	Water / Sewage / Sec. Treated Indl. Effluent / Air Application	Indl. Effluent / Bio-Gas / Chemicals or Corrosive Application
Bellows	SS 304 (ASTM A 240 Tp. 304)	SS 316 (ASTM A 240 Tp. 316)
Internal Sleeves / Liners	SS 304 (ASTM A 240 Tp. 304)	SS 316 (ASTM A 240 Tp. 316)
Weld End Pipe	CS / MS	SS 316L
Flanges	IS:2062 with drilling as per IS:1538, PN10	IS:2062 with drilling as per IS:1538, PN10 with SS lining (all wetted portion with SS lining)
Tie / Limit Rods	Carbon Steel (CS) as per IS 1367	SS 316
Nut, Bolt , Hardware	CS as per IS 1367	SS 316

Note: For Chemical (Alum, polyelectrolyte, etc.) or Corrosive application the above specified MOC are minimum and higher / better / suitable MOC shall be provided as per the nature of chemical / fluid.

❖ **ELECTRONIC WEIGHING SCALES**

Two numbers of electronic weighing scales shall be supplied, one of them having a weighing capacity of 2,500/3000 kg. and another having 500kg capacity, which forms part of the job / scope of supply of this tender.

Design and construction requirements:

- The weighing scale shall be of platform type, consisting of compound levers, platform goods, and coupled to a dial type indicator.
- The design manufacture, testing erection and commissioning of the weighing scale shall conform to the latest revision of the relevant IS code.
- The platform shall be capable of accepting concentrated loads
- The 500 Kg weighing scale shall be used for weighing PAC / Alum blocks and other such chemicals which may be used for the water treatment process from time to time and the 2500/300Kg weighing scale shall be used for weighing chlorine tonners and the scale shall be adequately designed for this.

- **PAINTING/COATING OF MECHANICAL ITEMS/EQUIPMENT**

MS/CI/DI BODY OR PARTS OR STRUCTURE (GENERAL FOR PIPING AND PUMP/ BLOWER/ PROCESS OR SUH OTHER EQUIPMENT IF NOT PROVIDED AS SPECIFIC)

Painting shall be carried out with one coat of ~~red oxide/~~epoxy primer followed by two coats of epoxy paint after proper surface preparation as recommended by paint manufacturer/shot blasting prior to dispatch, to a total DFT of minimum 150 microns inclusive of priming (for equipment/gate/valves, etc. at manufacturer works before delivery).
Zinc rich epoxy primer and epoxy paint of approved quality shall be used for external and internal painting as applicable. The mix of zinc rich epoxy primer shall be prepared at work site not earlier then 15 minutes before applying the same on pipes and special surfaces. One coat of zinc rich epoxy primer of DFT 75 micron shall be applied along with two coats of epoxy paint DFT 40-45 micron and DFT 30-35 micron respectively. No thinner shall be added to ready mix paint without previous approval of the Employer's representative and the finishing coats on top of the primer coat shall only be applied after allowing the film to cure for at least 48 hours.
After application of zinc rich epoxy primer the surface should be cleaned by duster and inspected. If during inspection, any portion is found rusting the same shall be removed by emery paper and coated with zinc rich epoxy primer.

Mixed paint should be used within 3 to 4 hours of mixing or as recommended by manufacturer and fresh mixing shall be done for every new application. Every successive coat of paint shall be applied only after 48 hours of previous coat. Before applying the next coat, the surface should be properly cleaned by duster.

CED Coating i.e. Cathode electro deposition coating which is the latest technology for corrosion resistance with uniform coating is also permissible and preferable over conventional painting.

OPEN CHANNEL GATES/SLUICE GATES (THIMBLE MOUNTED GATES)
Following painting procedure shall be adopted for the gates (CI/DI/MS MOC):

Surface Preparation	: Blast clean to near white metal finish using shot blasting.
Priming	: One coat of red oxide primer.
Finish Painting	: Black bituminous paint for gate assembly. Minimum DFT 200 microns inclusive of priming. Yoke and Headstock to be provided with ~~red oxide~~ / epoxy primer and epoxy grey or such suitable shade of paint having minimum DFT 150 microns inclusive of priming.

For Stainless steel gates, SS gate assembly shall be shot/grit blasted, pickled and passivated before delivery.

EOT CRANE
Painting shall be carried out as specified above for MS/CI/DI parts or structure before delivery. However, the final coat shall be golden yellow color with black zebra marking wherever applicable.

SS BODY OR PARTS OR STRUCTURE OR ENCLOSURE OR PIPING
Shall be shot/grit blasted, pickled and passivated before delivery / before erection at site (as applicable).

NOTE:
1. For equipment (including valves, gates, etc.) if paint surface is observed to be damaged/ deteriorated during storage or erection of such at site, an additional coat/touch up of paint shall be provided at site as directed by engineer-in-charge prior to commissioning/acceptance of site by client.
2. The paint shade as per manufacturers' standards' can be accepted.

➢ DOCUMENTS SUBMISISON OF MECHANICAL ITEMS/EQUIPMENT

In general, the minimum document submission for various equipment/items shall be as described below or additional as required for review to be submitted by manufacturers'/vendors' (duly stamped by manufacturers'/vendors') for review and approval during detailed engineering/execution and prior to manufacturing.

Manufacturing shall be carried out as per approved drawings and documents only and after complying comments as applicable.

PUMP AND PUMP-MOTOR SET (CENTRIFUGAL/POSITIVE DISPLACEMENT/ PROGRESSIVE CAVITY (SCREW)/RECIPROCATING (DOSING), ETC.)

1. Product technical data sheet.
2. Preliminary outline dimensional drawing (GA Drawing) showing the details of pump and motor, suction, discharge connections and foundation details.
3. Performance curves showing capacity v/s total head, efficiency, NPSH required and power requirements ranging from run out to pump shut off for minimum, maximum and rated impeller diameter of the offered pump.
4. ISO efficiency curve (as applicable).
5. Typical cross sectional drawing showing internal features of pump, parts and their materials.
6. Torque – Speed curve of the pump (as applicable).
7. Quality Assurance Plan.

VALVES (SV/NRV/DPCV/BFV/KGV/BALL/AIR VALVE, ETC.), SLUICE GATES, OPEN CHANNEL GATES

1. Product technical data sheet (valve torque shall be provided for electric/pneumatic actuator operated valve)
2. General outline dimensional drawings.
3. Cross sectional drawing showing constructional details with part list with their quantity and MOC confirming to relevant standards.
4. QAP of the product.

Additional Documents for ELECTRIC ACTUATOR OPERATED VALVES

1. Actuator data sheet (shall include opening & closing time and actuator torque selection with required safety factor over valve torque).
2. GA and wiring drawing of electric actuator.
3. Valve torque calculations.
4. Product catalogue.

EXPANSION BELLOWS

1. Product technical data sheet.
2. GA Drawings.
3. QAP of the product.

PIPES (METALLIC: CI/DI/MS, ETC. and NON-METALLIC: HDPE/uPVC/RPVC/PP ETC.)

1. Bill of materials.
2. QAP of the product.

MATERIAL HANDLING EQUIPMENT Viz. EOT/HOT CRANE/CPB/HOT-MONORAIL

1. Product technical data sheet.
2. Preliminary outline dimensional drawings.
3. Requirement of Girders/ISMB including minimum required size with all calculations.
4. Wiring diagram of panel.
5. QAP of the product.

MANUAL TYPE COARSE SCREENS

1. Product technical data sheet.
2. GA drawing.
3. Hydraulic calculation for head drop across screen for design/peak flow @ 50% clogging.
4. GAD, wiring and schematic diagram with BOM for control panel or recommended schematic and wiring diagram (as applicable).
5. Recommended cable schedule (as applicable).
6. QAP of the product.

CHLORINATION SYSTEM, CHLORINE SCRUBBER / LEAK MITIGATION SYSTEM

1. P and ID of chlorination system.
2. Bill of materials.
3. Product technical data sheet and dimensional drawing of various components of system.
4. Lay out drawing of installation.
5. GAD/Recommended installation drawing of chlorination system.
6. GAD of chlorine tonner.
7. GAD/Recommended installation drawing of chlorine scrubber (as applicable).
8. GAD, wiring and schematic diagram with BOM for control panel or recommended schematic and wiring diagram (as applicable).
9. QAP of the product.

PROCESS EQUIPMENT-GRAVITY SETTLING TANKS

(GRIT/DETRITOR MECHANISM, PRIMARY CLARIFIER, SECONDARY CLARIFIER, CLARI-FLOCCULATOR, REACTOR CLARIFIER, SLUDGE THICKENER etc.)

1. Product technical data sheet.
2. GA drawing.
3. Recommended Civil GA drawing.
4. QAP of the product.

AIR/GAS BLOWERS (ANY TYPE) and COMPRESSORS

1. Product technical data sheet.
2. GA and cross section drawing.
3. Performance curves.
4. Acoustic hood details (if applicable).
5. Actual flow calculation at design ambient, relative humidity and site altitude.
6. GAD, wiring and schematic diagram with BOM for control panel (if forming part of blower supply/part of blower skid).
7. Soft starter/VFD sizing ~~and selection after de-rating~~ (if forming part of blower supply/part of blower skid).
8. QAP of the product.

AGITATOR/MIXER

1. Product technical data sheet.
2. GA drawing.
3. Installation/Layout drawing (as applicable).
4. QAP of the product.

Note: The data sheet and GAD as specified for equipment/item shall also be considered to include coupled items like electrical drives/motor including its performance curves, electric actuators including its wiring diagram, pneumatic actuators etc. as applicable.

- **INSPECTION AND TESTING**

Inspection of offered equipment/items at manufacturers' works' shall be done by the Client/ PMC/TPI representatives as specified here in / as per approved inspection plan. Inspection shall be carried out as per relevant and applicable inspection and testing standards viz IS/BS/API etc. and as per approved quality assurance plans, technical data sheets, documents and drawings.

Inspection Criteria of Various Major Equipment/Items at Manufacturers' Works:

The Manufacturers'/OEM/Vendors' shall provide all instrument and equipment required to carry out applicable tests. The instruments shall be calibrated and certified by an approved independent testing authority preferably NABL accredited with valid calibration certificates as on date of inspection.

The inspection category and brief description of tests to be carried out for various equipment is as follows.

- **PUMP AND PUMP-MOTOR SET (CENTRIFUGAL/POSITIVE DISPLACEMENT/ PROGRESSIVE CAVITY (SCREW)/RECIPROCATING (DOSING), ETC.)**

HYDROSTATIC TEST
- A standard hydrostatic test shall be conducted on the pump casing with water at 1½ times the maximum discharge pressure on the head characteristic curve or 2 times the rated pressure whichever is higher.
- Unless otherwise stated in data sheet, the hydrostatic test on casing shall be conducted for minimum duration of 30 minutes.
- Manufacturer shall provide internal test certificates of hydrostatic test for review and acceptance by PMC and Client.

MECHANICAL BALANCING
- Major rotating components of the pumps like impellers, shaft, shaft sleeve etc. shall be individually statically as well as dynamically balanced preferably at rated speed.
- Vendor for PMC/Client's approval shall provide necessary test certificates.

MATERIAL TEST CERTIFICATES
- Material test certificates for the various pumps components shall be furnished for PMC/Client's review and approval as stated in the data sheet.

VISUAL INSPECTION
- Entire lot as per tender/BOQ shall be offered for visual inspection. The pumps shall not be painted before visual inspection and carrying out performance testing.

PERFORMANCE TESTING
Pump shall be tested for its full operating flow and head range.

Test shall be carried out for rated discharge and maximum discharge. Each pump shall be tested at its rated speed with preferably with **JOB** or shop motor of required rating and speed for its entire working range.

During pump testing, readings to the extent possible shall be taken to correspond to the net effective lift specified in the data sheet, and cover its full working range from its closed valve condition to run out condition i.e. when delivery valve is fully opened. Flow-Head, Flow-Power and Flow-Efficiency curves shall be drawn based on readings of tests carried out. The curves produced shall be used to determine the capacity of pump sets to meet guaranteed performance at site at rated speed.

PERFORMANCE WITNESS

1. **CENTRIFUGAL PUMPS – ANY TYPE (HSCF/VT /SCF/ HNC-VNC / SUBMERSIBLE/ POLDER/ MONO BLOCK/MONO SUBMERSIBLE ETC.)**

Pump (Based On Drive Motor Rating)	**Pump Performance Test to be Witnessed/Reviewed for each duty and type preferably with JOB MOTOR (Also see notes below)**
Up to 30kW motors	Visual/Performance test witnessing not required. Vendor to submit internal test certificates for review, approval and dispatch clearance as per note given below prior to dispatch.
> 30kW up to 160 kW motors	25% quantity or minimum 1 No. whichever is higher per duty/type.
> 160kW	50% quantity or minimum 1 No. whichever is higher per duty/type.
Notes: (1) Manufacturer shall test all the pumps internally and shall provide their internal test records along with dynamic balancing, material test certificates for all major parts as per tender. Hydrostatic test certificate, dimensional check certificates etc. as per approved QAPs and data sheet, of each pump for review, record and dispatch clearance prior to dispatch of pumps. **(2)** Vendor shall provide certified parallel operation curve for pumps where more than two pumps are incorporated in BOQ along with individual pumps performance test witnessing. (3) HSCF/VT/HNC-VNC **Pumps with drive motor ratings > 45kW to < 160 kW, ONE JOB motor** of each type and rating, out of the project (tender) lot, shall be sent to the pump manufacturers' works for performance testing of pump-motor assembly set. In case of testing of pump(s) with job motor(s), witnessing of inspection test of motors @ motor manufacturers' works shall stand waived and if pump(s) are to be performance tested with shop motor(s), inspection tests of motors shall be witnessed by the Client/PMC/TPI @ manufacturers' works as specified in technical specifications of electrical works.	

2. **DOSING PUMPS**

Pump (Based On Drive Motor Rating)	**Pump Performance Test to be Witnessed/Reviewed for each duty and type (Also see notes below)**
Up to 5.5kW motors	Visual/Performance test witnessing is not required. Vendor to submit test certificates for review/approval and dispatch clearance as per note given below prior to dispatch.
> 5.5 kW motors	25% quantity or minimum 1 No. whichever is higher per duty/type.
Notes: (1) Manufacturer shall test all the pumps internally and shall provide their internal test records along with dynamic balancing, material test certificates for all major parts as per tender, hydrostatic test certificate and dimensional check certificates etc. as per approved QAP and data sheet of each pump for review, record and dispatch clearance prior to dispatch of material. **(2)** Vendor shall provide parallel operation curve for pumps where more than two pumps are incorporated in BOQ along with individual pumps performance testing witnessing.	

- **VALVES (SV/NRV/DPCV/BFV/KGV/BALL/AIR VALVE)**

HYDROSTATIC TEST

- A standard hydrostatic test shall be conducted on the body and seat (with water) of valves at required test pressure depending on PN ratings/design pressure rating(s) of valves for minimum duration of 2 minutes or as specified in applicable testing standards.

- Manufacturer shall provide internal test certificates of hydrostatic test for review and acceptance by PMC and Client.

MATERIAL TEST CERTIFICATES

- Material test certificates for the various components of valves shall be furnished for PMC/Client's review and approval as stated in the data sheets.

VISUAL INSPECTION & VERIFICATION of DIMENSIONS

- Entire lot as per tender/BOQ shall be offered for visual inspection and verification check of dimensions. The valves shall not be painted before visual inspection and carrying out performance testing.

PERFORMANCE TESTING

- Valves shall be tested for operation as per applicable standards.

- Electric actuator operated valves shall be tested only on job electric actuator and shall verify operation time (Full open to full close in one cycle).

PERFORMANCE WITNESS

Size of Valves	**Performance Test to be Witnessed/Reviewed for each size/ rating and type (Also see note below)**
Up to 300mm diameter	Visual/Performance witnessing is not required. Vendor to submit test certificates for review/approval and dispatch clearance as per notes given below prior to dispatch.
> 300mm diameter	10% quantity or minimum 1 number whichever is higher per size/ rating and type for hydro test and rest shall be review of internal documents.
Note: Manufacturer shall test all the valves internally and shall provide their internal test records for hydrostatic test along with material test certificates for all major parts as per tender, dimensional check certificates, actuator internal test records for valve etc. as per approved QAP and data sheets of valve type for review, record and dispatch clearance prior to dispatch of materials.	

- **OPEN CHANNEL GATE**

MATERIAL TEST CERTIFICATES

- Material test certificates for the various components viz. frame, side guides, shutter, rubber seals and spindle etc. shall be furnished for PMC/Client's review and approval as stated in the data sheets.

VISUAL INSPECTION & VERIFICATION of DIMENSIONS

- Entire lot as per tender/BOQ shall be offered for visual inspection and verification check of important dimensions.

OTHER TESTS

- **Movement Test**
  Movement test shall be conducted in assembled condition using stems and headstock. The gate should be operated once from full close to full open and back to full close condition with a maximum force of 135 Newton-meter on the crank or hand wheel.

- **Seat Clearance Check**
  With the gate in closed condition, 0.1mm thick feeler gauge should not pass through the sealing faces.

- **PMI Test**
  Positive Material Identification (PMI) test to be conducted for seating/sealing faces, rubber seal retainer bar and stem/spindle during inspection.

- **DFT Measurement**
  DFT of paint is be measured with paint thickness measurement gauge during the inspection.

- Electric actuator operated valves shall be tested only on job electric actuator and shall verify operation time (Full open to full close in one cycle).

PERFORMANCE WITNESS

Size/Area of Open Channel Gate (Shutter)	**Performance Test to be Witnessed/Reviewed for each size, type and class of Sluice Gate (Also see note below)**
Up to 1m^2 area	Visual/Performance witnessing is not required. Vendor to submit internal test certificates for review/approval and dispatch clearance as per note given below prior to dispatch.
> 1 m^2 area	10% quantity or minimum 1 number whichever is higher per size of gate/shutter.
Note: Manufacturer shall test all the gates internally and shall provide their internal test records as specified above along with material test certificates for all major parts as per tender, clearance check test, leakage test, movement test, dimensional check certificates, actuator internal test records for gates etc. as per approved QAP and data sheets of open channel gate for review, record and dispatch clearance prior to dispatch of materials.	

- **SLUICE GATE**

MATERIAL TEST CERTIFICATES

- Material tests certificates for all important components of gates such as thimble, frame, shutter, seat facings, spindle and rubber seals etc. to be furnished at the time of inspection.

VISUAL INSPECTION & VERIFICATION of DIMENSIONS

- Entire lot as per tender/BOQ shall be offered for visual inspection and verification check of important dimensions.

OTHER TESTS

- **Movement Test**
  Movement test shall be conducted in horizontal/vertical assembled condition using stems and headstock. The gate should be operated once from full close to full open and back to full close condition with a maximum force of 135 Newton-meter on the crank or hand wheel.
- **Shop Leakage Test**
  Shop leakage test by applying unseating hydraulic pressure will be conducted with gate mounted vertically on a test bench. A hydrostatic pressure equal to maximum seating/ unseating head shall be applied to gate at centerline of gate opening from the back, i.e. unseating face of the gate in closed position, through pump. A suitable scaled calibrated pressure gauge put on the unseating face of the gate shall indicate reading equal to unseating pressure head. Water leakage through the gate under above condition shall be collected in a collection pan and measured.

  The leakage so measured should not exceed the limit of 2.5, 3.5 and 4.5 LPM per meter sealing perimeter for class I, class II and class III sluice gates as stated in the IS: 13349 (1992).

  No alternate testing arrangement will be permitted in place of above method. Gates can be applied with a coat of primer to prevent rusting due to water exposure during testing.

- **Hydrostatic Body Test**

After the leakage test, hydrostatic body test will be conducted by applying hydrostatic pressure equal to 1.5 times the maximum operating head on the gate for 5 minutes continuously. No permanent deformation in casting should be observed.

- **Torque Testing at Operating Head**
  Torque test at operating head would be conducted at applicable head at manufacturer's shop for gates up to 2000mm x 2000mm size.

- **Seat Clearance Check**
  With the gate in closed condition, 0.1mm thick feeler gauge should not pass through between seat facings.

- **PMI Test**
  Positive Material Identification (PMI) test to be conducted for sealing/seating faces, rubber seal retainer bar (if applicable) and stem/spindle during the inspection.

- Electric actuator operated valves shall be tested only on job electric actuator and shall verify operation time (Full open to full close in one cycle).

PERFORMANCE WITNESS

Size, Class and Type of Sluice Gate	**Performance Test to be Witnessed/Reviewed for each size, type and class of Sluice Gate (Also see Note below)**
Up to 1000mm dia./square (up to 1 m^2 area)	Visual/Performance witnessing is not required. Vendor to submit test certificates for review/approval and dispatch clearance as per note given Below prior to dispatch.
> 1000 mm diameter/square (> 1 m^2 area)	10% quantity or minimum 1 number whichever is higher per size/ class and type.
Note: Manufacturer shall test all the sluice gates internally and shall provide their internal test records for hydrostatic test along with material test certificates for all major parts as per tender, clearance check test, leakage test, movement test, dimensional check certificates, actuator internal test records for gates etc. as per approved QAP and data sheet of sluice gate for review, record and dispatch clearance prior to dispatch of material.	

- **EXPANSION BELLOWS**

HYDROSTATIC TEST

- A standard hydrostatic test shall be conducted on bellows at required test pressure depending on PN ratings/design pressure rating(s) of bellows for minimum duration of 15 minutes or as specified in applicable testing standards.

- Manufacturer shall provide internal test certificates of hydrostatic test for review and acceptance by PMC and Client.

MATERIAL TEST CERTIFICATES

- Material test certificates for the various components of bellows shall be furnished for PMC/Client's review and approval as stated in the data sheets.

VISUAL INSPECTION & VERIFICATION of DIMENSIONS

- Entire lot as per tender/BOQ shall be offered for visual inspection and verification check of dimensions. The bellows shall not be painted before visual inspection and carrying out performance testing.

PERFORMANCE TESTING

- Bellows shall be tested for axial expansion and compression test as per applicable standards.

- Dye penetration test (DPT) shall be carried out for weld joints on expansion bellows exceeding size of 1 meter (NB Dia.) selected randomly from entire project (tender) lot.

PERFORMANCE WITNESS

Size of Expansion Bellows	**Performance Test to be Witnessed/Reviewed for each size/rating and type (Also see note below)**
Up to **500mm** diameter	Visual/Performance test witnessing is not required. Vendor to submit test certificates for review/approval and dispatch clearance as per notes given below prior to dispatch.
> 500mm diameter	10% quantity or minimum 1 number whichever is higher per size/ rating and type for hydro test and rest shall be review of internal documents.
Note: Manufacturer shall test all the expansion bellows internally and shall provide their internal test records for hydrostatic test along with material test certificates for all major parts as per tender, dimensional check certificates, actuator internal test records for valve etc. as per approved QAP and data sheets of expansion bellows for review, record and dispatch clearance prior to dispatch of materials.	

- **PIPES (METALLIC: CI/DI/MS, ETC. and NON-METALLIC: HDPE/uPVC/RPVC/PP ETC.) AND CI/DI FITTINGS**

VISUAL INSPECTION & VERIFICATION of DIMENSIONS

- Entire lot as per tender/BOQ shall be offered for visual inspection and verification check of dimensions.
- Mass/Weight check and thickness check shall be carried out as per approved QAPs and applicable standards.

HYDROSTATIC TEST

- A standard hydrostatic test shall be conducted on pipes at random at required test pressure for minimum specified duration in applicable testing standards.

- All other tests shall be carried out as per applicable standards.

PERFORMANCE WITNESS

Size, Class and Type of Pipes and Fittings	**Performance test to be Witnessed/Reviewed for each size/class and type of pipe and fittings (Also see notes below)**
Up to 300mm diameter	Performance witnessing is not required.
> 300mm diameter and Up to 900mm diameter	10 % quantity or minimum 1 number whichever is higher per type size/class/length and type.
> 900mm diameter	25% quantity to be witnessed.
Notes: **1)** Manufacturer shall test all the pipes & fittings internally and shall provide their internal test records for hydrostatic test along with material test certificates, mass/weight check statement, dimensional check certificates etc. as per BOM and as per approved QAP for review, record and dispatch clearance prior to dispatch of materials. **2)** For pipes **above 300mm dia. and up to 900mm** dia. size, if the total quantity required for entire pumping system/project is **less than 250meters**, performance test is not to be witnessed. However, conditions mentioned at serial number 1) here in must be adhered to and complied with to the satisfaction of Engineer in charge/ PMC. **3)** For pipes **above 900mm dia.** size, if the total quantity required for entire pumping system/project is **less than 150meters**, performance test is not to be witnessed. However, conditions mentioned at serial number 1) here in must be adhered to and complied with to the satisfaction of Engineer in charge/ PMC.	

4) For all fittings of all sizes if the total weight of total quantity required for entire pumping system/project is less than **750kg**, performance test is not to be witnessed. However, conditions mentioned at serial number 1) here in must be adhered to and complied with to the satisfaction of Engineer in charge/PMC.
5) For all fittings of all sizes if the total weight of total quantity required for entire pumping system/project **exceeds 750kg**, performance tests shall be witnessed as per governing standards and approved QAPs and other relevant documents and tender specifications.

- **MATERIAL HANDLING EQUIPMENT Viz. EOT/HOT CRANE/CPB/HOT-MONORAIL**

MATERIAL TEST CERTIFICATES

- Material tests certificates for all important components of the equipment hook, wire rope, brakes etc. to be furnished at the time of inspection.

VISUAL INSPECTION & VERIFICATION of DIMENSIONS

- Entire lot as per tender/BOQ shall be offered for visual inspection and verification check of important dimensions.

OTHER TESTS

- All motorized material handling equipment shall be tested for overload tests at 125% of the rated load.
- All manual chain pulley blocks/HOT etc. shall be tested for overload tests at 150% of the rated load.
- Speed of lifting, long and cross travel as well as and deflection check shall be conducted as per governing standards.

PERFORMANCE WITNESS

Type & Capacity of Material Handling Equipment	**Performance Test to be Witnessed/Reviewed for each type and capacity**
(Electric/Manual) CPB/HOIST/HOT-Monorail/ Chain Hoist – Any capacity EOT/HOT Crane - **Up to 3MT**	Visual/Performance witnessing is not required. Manufacturer shall test all the CPB/Hoist, HOT/EOT (up to 3 MT) internally and shall provide their internal test records along with material test certificates for all major parts as per tender, dimensional check certificates etc. as per approved QAP and data sheet of CPB/Hoist, HOT/EOT (up to 3 MT) for review, record and dispatch clearance prior to dispatch of materials.
EOT/HOT Crane **> 3MT**	10% Quantity or Minimum 1 No. whichever is higher per size (capacity) and type shall be witnessed at manufacturers' works for performance test as per approved QAP and data sheet.

- **CHLORINATION SYSTEM, CHLORINE SCRUBBER/LEAK MITIGATION SYSTEM** Visual/Performance witnessing is not required.

  The complete chlorination system shall be offered for inspection and testing after installation at site.

- **PROCESS EQUIPMENT-GRAVITY SETTLING TANKS (GRIT/DETRITOR MECHANISM, PRIMARY CLARIFIER, SECONDARY CLARIFIER, CLARI-FLOCCULATOR, REACTOR CLARIFIER, SLUDGE THICKENER etc.)**

  Visual/Performance witnessing is not required.

  Manufacturer shall carry out internal inspection for the offered equipment and shall provide their internal test records for dimensional check certificates along with material test certificates for all

major parts as per tender and approved QAP and data sheet for review, record and dispatch clearance prior to dispatch of materials.

- **AIR AND GAS BLOWERS–ROOTS TYPE (TWIN/TRI-LOBE), SCREW TYPE, HYBRID BLOWERS**

HYDROSTATIC TEST

- A standard hydrostatic test shall be conducted at 2 times the maximum working pressure of the blower.
- Manufacturer shall provide internal test certificates of hydrostatic test for review and acceptance by PMC and Client.

STRIP TEST

- A standard strip test shall be conducted on minimum 1 number of blower and the clearance shall be within the limits including applicable tolerances as per standards.
- Manufacturer shall provide internal test certificates of strip test for review and acceptance by PMC and Client.

MECHANICAL BALANCING

- Major rotating components of the blower shall be individually statically as well as dynamically balanced preferably at rated speed as per governing and applicable standards.
- Vendor for PMC/Client's approval shall provide necessary test certificates.

MATERIAL TEST CERTIFICATES

- Material test certificates for the various components shall be furnished for PMC/Client's review and approval as stated in the data sheet.

MECHANICAL BALANCING

- Major rotating components of the blower shall be individually statically as well as dynamically balanced preferably at rated speed as per governing and applicable standards.
- Vendor for PMC/Client's approval shall provide necessary test certificates.

VISUAL INSPECTION

- Entire lot as per tender/BOQ shall be offered for visual inspection. The blowers shall not be painted before visual inspection and carrying out performance testing.

PERFORMANCE TESTING

Blower shall be performance tested as per BS 1571/applicable standards.

PERFORMANCE WITNESS

Blower Rating (Based On Drive Motor Rating)	**Performance Test to be Witnessed/Reviewed for each duty and type preferably with JOB MOTOR (Also see note below)**
Up to 30kW motors	Visual/Performance witnessing is not required. Vendor to submit test certificates for review/approval and dispatch clearance as per note given below prior to dispatch.
> 30kW and Up to 160kW motors	10% quantity or minimum 1 No. whichever is higher per duty/type.
> 160kW	25% quantity or minimum 1 No. whichever is higher per duty/type.
Note: 1) Manufacturer shall test all the blowers internally and shall provide their internal test records along with material test certificates for all major parts as per tender, hydrostatic test certificate,	

dimensional check certificates, dynamic balancing etc. as per approved QAP and data sheet of each blower for review, record and dispatch clearance prior to dispatch of materials.

2) Blowers with drive motor ratings ≥ 45kW, ONE JOB motor of each rating, out of the project (tender) lot, shall be sent to the blower manufacturers' works for performance testing of blower. In case of testing of blower(s) with job motor(s), witnessing of inspection test of motors @ motor manufacturers' works shall stand waived and if blower(s) are to be performance tested with shop motor(s), inspection tests of motors shall be witnessed by the Client/PMC/TPI @ manufacturers' works as specified in technical specifications of electrical works.

- **BLOWERS**

MATERIAL TEST CERTIFICATES

- Material test certificates for the various components viz. impeller, scroll, main frame, shaft, berings etc. shall be furnished for PMC/Client's review and approval as stated in the data sheet.

ELECTRICAL EQUIPMENT

- TC for dielectric test of motor and control / starter panel and other electrical accessories/components shall be submitted for review and acceptance by the Client/PMC.

VISUAL INSPECTION

- Entire lot as per tender/BOQ shall be offered for visual inspection.
- Dimensions, sheet and paint thickness and BOM shall be verified by the Client/PMC/TPI.

PERFORMANCE TESTING

Turbo blowers shall be performance tested as per governing standards at manufacturers' works.

PERFORMANCE WITNESS

Blower Rating	**Performance Test to be Witnessed/Reviewed for each duty and type (Also see note below)**
For All Ratings	25% quantity or minimum 1 No. whichever is higher per duty/type.

Note: 1) Manufacturer shall test all the blowers internally and shall provide their internal test records along with material test certificates for all major parts, dimensional check certificates, dynamic balancing etc. as per approved QAP, data sheet and drawings of each blower for review, record and dispatch clearance prior to dispatch of materials.
2) Blower to be subjected to functional testing (on no-load condition) and which is to be witnessed shall be selected randomly by Client/PMC/TPI.

- **AGITATOR/MIXER**

Visual/Performance witnessing is not required.

Manufacturer shall carry out internal inspection for the offered equipment and shall provide their internal test records for dimensional check certificates along with material test certificates for all major parts as per tender and approved QAP and data sheet for review, record and dispatch clearance prior to dispatch of materials.

IMPORTED PROCESS OR OTHER EQUIPMENT

Imported equipment like

- AIR/GAS BLOWERS,
- PUMPS ETC. AS APPLICABLE

For all process or other major equipment specified above or such other which are imported (bought from outside India), Contractor shall arrange to inspect such equipment by reputed third party inspection agency eg SGS/Bureau Veritas/TUV as per approved quality assurance and inspection plans at manufacturers' works without any extra cost. The test/performance certificates and relevant supporting

documents shall be submitted to Client/PMC/TPI for review and approval. The imported equipment/materials shall be dispatched only after obtaining dispatch clearance from Client.

NOTES:
For all major equipment/items specified above, where factory inspections are exempted as clearly specified above, all tests as per relevant and applicable standards as well as approved QAPs, data sheets, documents and drawings must be carried out by the manufacturers'/vendors etc. and test certificates, MTCs etc. shall be submitted to the PMC/TPI prior to dispatch for getting dispatch clearance of the Client/PMC/TPI.

All other items not explicitely mentioned here but are in the scope of the tender (project) are exempted from performance tests @ manufacturers' works' to be witnessed by Client/PMC/TPI. However all tests as per applicable governing standards should be carried out by the manufacturers' and such test reports along with MTCs, dimensional verification certificates (if and as applicable) shall be submitted to the Client/PMC/TPI for review and acceptance for getting get dispatch clearance.

All expenditure pertaining to inspection including to and fro travel, local conveyance, lodging and boarding etc. shall be borne by the Contractor for minimum 2 representatives of Client/PMC/TPI Agency.

The Client or his authorized representative may visit the works during manufacture of various mechanical equipment/materials to assess the progress of work as well as to ascertain that only quality raw materials are used for the same. He shall be given full assistance to carry out stage inspection. Client's representative shall be given minimum two weeks advance notice for witnessing the final testing.

Field tests as per approved procedures/procedures available with Engineer-in-charge or his authorized representative shall be performed on the mechanical system/equipment before it is being put into service. All test equipment and instruments shall be arranged by the Vendor/Contractor. Test reports shall be approved by the Engineer-in-charge before acceptance of the equipment and complete plant.

APPROVED VENDOR LIST FOR MECHANICAL EQUIPMENT

Centrifugal / Centrifugal Non-Clog Pumps (Hor. / In-Line)	Beacon Weir / Jyoti / Kirloskar / KSB / Mather & Platt (Wilo) / Worthington / Grundfoss / ITT-Xylem
Vertical Turbine (V.T.) Pumps	Kirloskar / Mather & Platt (Wilo) / Worthington (WPIL) / Jyoti
Subm. Centrifugal / Subm. Centrifugal Non-clog Pumps	Aqua / Kirloskar / Kishor / KSB / ABS / ITT-Flyght (Xylem) / Grundfoss / Xylem / Mather & Platt / Jyoti
Drain / Dewatering Pumps (Submersible / Horizontal)	Aqua / Kirloskar / Kishor / KSB / MBH / Wilo (M&P) / Lubi / Pullen
Screw Pump	Roto / Netzch / Tushaco / Seepex / U T Pump
Metering / Dosing Pumps	Swellore / V.K.Pumps / Shapotools / S.R. Metering / Milton Roy/ Positive Metering
Sluice Valves	Kirloskar / IVC / IVI / Audco / R&D Multiple / Keystone / Fouress / GM Engg. / Vag / / AVK / Durga / Hawa Engineers
Non Return Valves (Single / Multi door) / Dual Plate Check Valves	Kirloskar / IVC / IVI / Audco / R&D Multiple / Keystone / Fouress / GM Engg. / Vag / / AVK / Durga / Hawa Engineers
Butterfly Valves	Kirloskar / IVC / IVI / Audco / R&D Multiple / Keystone / Fouress / GM Engg. / Vag / / AVK / Durga / Hawa Engineers
Kinetic Air Valves	Kirloskar / IVC / IVI / Audco / R&D Multiple / Keystone / Fouress / GM Engg. / Vag / / AVK / Durga / Hawa Engineers
Knife Gate Valve	Jash / Fouress / Vass (Dezurick) / Vag / Orbinox / IVI
Sluice Gates / Open Channel Gates	Jash Engineering / IVC / IVI / R&D Multiple
Ball Valves	Audco / BDK-Weir / Intervalve / Kirloskar / Saunders / Mevada (Saturn) / Hi-Tech / Virgo / Hawa Engineers / Virgo
HOT/EOT Crane, Hoist and Pulley block.	Morris / Indef / Safex / W H Brady / Anker / Japs
Air Blower	Kay / Swam / Everest / Usha Compressors / Garden Denver / Aerzen
Agitator / Mixer	Remi / Schurtek / Fibre & Fibre / Milton Roy / Shivpad / Ceecon / Triveni / Rathi Vessels & Systems
Gear Boxes	Elecon / CPEC / Premium Transmission (PTPL) / Bonfiglioli / Radicon (PBL) / Shanthi Gears
D.I. Pipes	Electro Steel / Kejriwal / Lanco / Jindal / Electrotherm / Srikalahasthi
D.I. Double Flanged (DI DF) Pipes & Fittings.	Electro Steel / Kejriwal / Lanco / Kiswok / Jindal / Electrotherm / Srikalahasthi / Truform (DI pipe for DI DF Pipe manufacturing shall be as per approved make of DI Pipes only)
C.I. Pipes & fittings.	Electro Steel / Kejriwal / Upadhyaya / NJMW / Eskay (Howrah) / Oriental Castings / BIC
Chlorinator	Metito (Capital Control / DeNora) / Supreme (Evoqua / Chemical Injection Technologies) / Chlorotech / Banaco / Toshcon-Jesco / Aldoss / Sun Engg. Services
Chlorine Container	ISGEC / Anup
HDPE Pipes	Astral / Dutron / Duraline / Narmada / RIL (PIL) / Penwalt / Anjney / Jain Irrigation / Sangir / Supreme
PVC / uPVC / CPVC Pipes	Astral / Supreme / Prince / Dutron / Finolex / Jain Irrigation / Vectus Industries
M.S. / C.S. / G.I. Pipes	Jindal / Tata / Welspun / Asian / SAIL / Any reputed Mfr.

MS / GI Plates & Sheets	Arcelor Mittal / Tata / Jindal / SAIL / Asian
Air Compressor	Ingersoll-Rand / Khosla / Kirloskar / Chicago Pneumatic
Bearing for all equipment	SKF / FAG / NBC / NTN
Mechanical Seals	Eagle Seals (Sealol) / Durametallic / Burgman
Electric Actuator	Auma / Rotork / Emerson
Metallic Expansion Bellows	Dhruv / Precision / Technoflex / Precise Engg. / Flexican Bellows & Hoses / Flexpert Bellows / Sur Industries (Surflex) / Athulya Bellows / Stanfab Engineering
Manual Bar / Mesh Screen	Jash / Japs / HDO / Triveni / Auric / Shivpad / Apollo Screen
Process Equipment (Clari-Flocculator, Gravity Sludge Thickener, etc.)	Eimco-KCP / HDO / Shivpad / Triveni / Voltas / Geo Miller
Centrifuge	Humboldt / Alpha Laval / Hiller / Gea Westfalia
Air Conditionner	Blue Star / Carrier / Daikin / Hitachi / LG / O-General / Samsung / Voltas / Mitsubishi
Weighing Scale	Avery / Acme / Atco / Avon / Mettler-toledo
Office Furniture	Godrej / Blind Men's Association

The contractor shall distinctly understand that it will not be their prerogative to insist on a particular brand from the list, final selection will be done with the approval of Engineer in charge.

1.0 INTENT OF SPECIFICATIONS/SCOPE

1.1 This specification along with specific job requirements (if any) is intended to cover the design, engineering, supply, installation, testing and commissioning of entire electrical facilities/ equipment and items and accessories including consumable against lump sum price for entire treatmemt plant/facility as indicated here in and elsewhere covered in the scope of this tender.

1.2 It is not intended to cover all aspect of system design but to indicate the basic requirements only. Contractor shall ensure that detailed design and installation is carried out as per good engineering practices and shall meet requirements of safety, reliability, ease of maintenance & operation, aesthetics, scope for future expansion (if specified elsewhere in tender under scope of work or project description) and maximum interchangeability of the equipment.

"Scope of Schedule of Item" as mentioned herein are minimum and suggestive but not conclusive and binding. The contractor shall furnish all, but not limited to equipment, materials, accessories, and service as required fulfilling the performance of proposed new plant.

1.3 Bidder must quote the price according to intent, besides content of the of the tender. Engineer's/ Consultant's interpretation of the meaning of the specifications, drawings shall be final who shall have the right to accept or reject any material or work which in his assessment is not complete to meet the intent of this specification and/or applicable standards.

1.4 The equipment and accessories shall be complete in all respects and any device not included in this specification but essential for proper operation of the plant shall be deemed to be within the scope of this specification whether specifically mentioned or not.

1.5 Some parts of the total work may have tie ups with the existing system. Hence any commercial or technical implications thereof must be duly taken care of even if not mentioned/considered in this tender.

1.6 It is the responsibility of Bidder to visit and assess the site conditions for the purpose of this work.

1.7 Bidder shall also ensure to take care of existing works/piping/cabling, if any, during execution and ensure no damage is done and obstruction be resolved in consultation with engineer in-charge at no extra cost. In case of any damage, it is the responsibility of bidder to rectify the problem to the satisfaction of engineer in-charge at no extra cost.

1.8 The equipment items shall be supplied only as per approved vendor list for major items enclosed herewith as part of this tender document. Bidder shall furnish necessary technical catalogue and details and obtain approval for the make of items he proposes to procure before placement of order. The decision of Engineer-in-charge in the matter is final and binding. Approval for makes of items not mentioned in the approved list of vendors will also be required to be obtained from Engineer-in-charge before procuring the same.

1.9 Compliance with this specification and/or review of any of the vendor documents shall not relieve the vendor of his responsibility towards his contractual obligation with regard to the completeness and satisfactory operation of the plant.

2.0 SCOPE OF WORK

Design, Engineering, Supply, Installation, Testing and Commissioning of the entire electrical facilities including electrical equipment, control devices, fittings, cables/wires, conduits, hardware and consumable and also including all relevant works like termination, cable jointing, earth excavation/backfilling, structural works for equipment support, Hot dip galvanized ladder/perforated type medium duty (minimum 610 g/m^2 galvanizing) cable trays as per IS: 2629/FRP/GRP cable tray as per NEMA FG1 specification with minimum factor of safety 1.5 or higher as specified elsewhere, all allied civil works etc.

In outdoor areas cables shall be mostly laid directly buried underground with adequate mechanical protection wherever applicable/laid on overhead cable tray (Hot dip galvanized MS tray/FRP tray) with mechanical support structure. Where as in indoor areas, cables shall be laid in trenches/walls/ceilings/structures through suitable trays/cleats. Overhead cable tray (outdoors) shall be erected with minimum 5m clearance or higher as required at road crossing for vehicle/ truck movement without obstruction.

Installation of the contract work including furnishing labour (Skilled/Unskilled) and supervisory personnel inclusive of the services of an experienced engineer, having authorized and valid supervisory license is included in the scope of work/services.

All installation are to carried out as per the statutory requirements of local Electrical Inspectorate/IE rules/CEA Regulations/applicable IS Code/code of practices and obtaining statutory clearance from Electrical Inspectorate shall be in the scope of executing contractor including for Genset (Diesel/Gas) as applicable.

Electrical equipment shall meet the requirements of Indian Electricity Rules, CEA Notification, CPWD guidelines, State Regulations as amended up to date and relevant IS/IEC Codes of Practice. In addition, other rules and regulations as applicable to the work shall be followed. In case of any discrepancy, the most restrictive rule shall be binding.

2.1 SCOPE OF SCHEDULE OF ITEMS

"Scope of Schedule of Items" as mentioned here in are suggestive but not conclusive and binding. The contractor shall furnish all, and not limited to below equipment, materials and accessories and service, as required to fulfill the performance of proposed new plant. The general requirements as under.

Sr. No.	Item Description	Quantity
1	Strengthening / Modificaiton of existing 11KV HT power to be utilized for proposed plant work requirement & rectification, if required for client existing two pole structure located near PSC two pole structure, including SITC of RMU HT VCB Panel, if required for proposed plant requirements for onwards transmission as required for the electrical installation and satisfactory operation of plant as required as per electrical inspector / statutory requirement, same shall be provided by bidder at no extra cost as as explained in electrical scope of work in Chapter-03.	1 Lot
2	11 kV, Two/Four pole structure with DO type air break isolator/DO fuses/LA/ relevant insulators (Disc/Pin/Post) etc. of adequate rating along with required foundations, fencing, gates etc. (Minimum 1 Set with HT Breaker Panel or Min. 3 Sets Two pole structure or Four pole structure (1Incoming + 2 Outgoing) or more as required to meet site and statutory requirement. For distance of power supply company metering / GOD structure and client GOD structure / HT Breaker or from client GOD	1 Lot

	structure to client HT Breker panel exceeding beyond stipulated distance and if outddor type RMU panel or such required as per electrical inspector / statutory requirement, same shall be provided by bidder at no extra cost.)	
3a	11kV Outdoor type, 630Amps. 26 kA for 1 second, SF6 type extensible and motorized One way / Three way (1 Incoming + 2 Outgoing) smart Ring Main Unit (RMU) complete with 3VCB and FPI as per IS.	1 Lot
3b	11kV, 500 MVA (or higher as per system requirement), 3 breaker (1 incoming + 2 outgoing) panel indoor HV VCB switchgear panel with internal arc protection equal to short circuit current the system i.e. 26 kA for 1 second and complete with numerical protection relays. HV panel shall be as per IEC: 62271-200/IEEE 1584/IEC 60439.	1 Set (if required as per statutory norms)
4	11/0.433kV Dyn11, ONAN, outdoor type transformers energy efficiency level 2 as per IS: 1180 Part 1 (latest version), continuous duty with off load (off circuit)/~~On load (on circuit)~~ tap changer mechanism as specified elsewhere, Buchloz relay and other standard fittings/accessories, each of required rating to cater to the entire treatment plant load @ 80% loading. Required foundations, chain link fencing, gates etc. shall also be provided. The transformer shall be sized considering the diversity and load factor and voltage drop as specified in design basis/specifications elsewhere. Transformer sizing shall be restricted preferably to 2500kVA maximum. If transformer required is > 2500 kVA, then load shall be segregated optimally and transformers of lesser ratings (2 working + 1 standby of same capacity) feeding two PCC/PMCC shall be provided. Separate HV breaker feeders shall be provided for each transformer. Alternatively 2 working transformers and one common stand by transformer with common change over panel also is acceptable only if both PCC/PMCC being fed are in the same room. kVA rating to be specified by the Bidder along with necessary load calculations for plant peak load considering 100% stand by unit. Transformer sizing shall be based on motor rated PF i.e. without APFC/Fixed PF improvement capacitors.	2 Set
5	3 phase Aluminium Sandwich type bus duct IP 65, 65kA, design ambient of 50^0C with all accessories including copper flexibles at termination of equipment and GI supporting structure for transformer ratings 1000 kVA and above, one for each incomer.	Lot
6	LV/MV panels (PCC/PMCC/MCC)	Lot
6a	PCC/PMCC: 415V, 3 phase, 4 wire, minimum 50kA (1 second) or higher as per fault level requirement, PCC/PMCC (at Existing LT Room near Pump house-2) with necessary incomers (as required for each incoming supply - for each transformer/grid, DG set etc. as applicable), bus coupler(s) (between grid incomers, other/additional bus couplers if required as per design), with electrical/mechanical interlocks etc. and with fixed capacitor bank and 7% detuned reactor with thermostate at each grid incomer (minimum 3% of transformer rating, timer interlocked and in break up of approximately 50%, 25%, 15%, 10% of total, each with separate/MCB (D curve)/MCCB and interlock contact) and required outgoing power feeders, starter feeders, spare feeders etc. PMCC shall be also with one no. min. 200A MCCB feeder for MCC-1 Panel located at CCT cum panel Room / LT panel catewring to for Plot-B load , one no. min. 32/63A MCCB for MCC-2 Panel located at Admin building to cater to Plot-A load, 2nos. min. 45kW Star-delta starter for Sub. Pump set to be provided in existing GSR-1 to lift clear water from GSR-1 to existing GSR-2, two no. min. 250A MCCB Spare feeders (one on each side of bus coupler), etc. complete. Incomer and bus coupler ACB/MCCB ampere rating shall be with minimum 20% margin over the required ampere rating based on rated current of transformer.	1 Set

6b	MCC PANEL Bidder/Contractor shall consider to provide MCCs to be housed in MCC room at other suitable location in plant as per their design. All MCC panel shall be provided with two incomers (one incomer as standby) with electrical and mechanical interlocking between the two. Panels forming part of the various Mechanical Equipment to be supplied by the Contractor and which are considered part of the respective equipment, are not included in the above. Outdoor starter/control panels/power panels wherever provided shall be with canopy and double door. Panel shall be fabricated from SS 304 and all hardware, hinges supporting structure etc shall be of SS.	Lot
6c	PDB/MLDB/LDB (MCB type TPN, LDB, typically 4/6/8 way per phase, up to 20A single pole per way). Outdoor PDB/MLDB shall be with double door and with canopy.	Lot
7	Automatic (Dynamic) power factor improvement capacitor panel to maintain minimum power factor as per specifications. 7% detuned reactor with thermostat, 440V shall be provided in series with 525V capacitor if working VFD load is more than 50% of total load. KVAr rating of capacitor shall be suitable for reactor rating. Minimum 10% margin to be considered above required capacitor as per calculation. At PCC/PMCC, 2 Nos. APFC panels shall be provided as a minimum, one on each bus of PCC/PMCC, with minimum 70% of rated design each or higher as required. Additionally APFC panel can also be considered at MCC level.	Lot
8	LV motors, IE3 class, S1 duty; for Crane/Hoist application S4 duty; for Submersible Pumps - equivalent to IE2 class, S1 duty.	Lot
9	Local start/stop push button control station (Polycarbonate enclosure), IP 65	Lot
10	Indoor and Outdoor illumination system to achieve average lux level as mentioned elsewhere in this electrical specifications. Indoor and outdoor lighting fixtures shall be LED type only. Lighting poles shall be GI Tubular swaged/GI Octagonal type. Welding sockets with necessary cabling/wiring, MDBs/LDBs, poles, fixtures etc.	Lot
11	HV/LV Power/Control Cables: (multi-stranded conductor, with extruded inner sheath) a) 11kV XLPE (E), Aluminum conductor, armoured power cable. (including existing HT cable replacement or any other HT cable required as specified in scope for electrical work in Chapter-03 or any other as required to complete the work in all respects) b) 1.1kV, XLPE/PVC insulated, Alu. conductor, armoured power cable of suitable size and cores. Aluminium power cable for 6 sq mm and above sizes only and for 2.5 sq mm, 4 sq. mm only multi-strand Copper cable shall be used. c) 1.1kV, PVC/XLPE insulated, multi-strand Copper conductor, armoured, Control Cable of 2.5 sq mm suitable number cores for LCS, ammeter etc. minimum 1 no. or 20% spare cores to be provided. d) 1.1kV PVC/XLPE insulated, Copper, 4 core armoured cable of required size (Minimum 2.5 sq mm or higher as required as per load requirement) for lighting cable. e) Other cables as required.	Lot
12	Complete earthing system with maintenance free earth electrodes, chemical earthing Pits, earthing strip (hot dip galvanized GI/Copper)	Lot
13	Cable glands (double compression Ni plated Brass glands), sockets, steel, other erection hardware and accessories etc.	Lot
14	Supply/fabrication/erection/painting of MS structural steel as required for cable trays as per IS: 2629/supports/hangers/cleats etc. to complete entire electrical works. Cable trays shall be hot dip galavanized (medium duty	Lot

	minimum 610 g/m^2 galvanizing). Alternately cable trays of FRP (GRP) cable tray as per NEMA FG1 of suitable size and strength can be accepted. Hardware used shall be hot dip galvanized/SS.	
15	Any other internal wiring / point wiring / electrification work and including required switches, plug points, power sockets / points, etc.; industrial power sockets, fans, exhaust fans, safety accessories, etc.	Lot
16	Surge protection shall be provided on power system equipment fed from overhead line systems. Usually this shall apply to HV overhead supplies feeding to sites. In this case the surge protection shall be provided by the contractor at incoming and outgoing of HV panel. Surge protection shall be provided at incomer of each LV panel (PMCC/MCC).	Lot
17	DG Set of required rating to cater to 100% of working load of entire Plant at peak flow @ 80% loading along with AMF Panel to operate entire plant load on DG Set in case of power failure. (Shall be min. 320KVA rating or higher as required)	Lot
18	Any other work as required to complete the work in all respects.	Lot

Note: It is not the intent to specify herein completely, all details pertaining to design, shop testing, installation, field testing and commissioning. However, these shall conform in all respects to high standards of engineering design and workmanship, meeting the requirements of all applicable codes and standards including local statutory requirements. The scope shall include all the specified accessories/items as well as other any required items/accessories, whether specified or not, for satisfactory/safe operation of the entire electrical system and for meeting all statutory requirements.

3.0 SPECIFICATIONS OF ELECTRICAL WORKS (GENERAL)

General

Following clauses specify general electrical requirements and standard of workmanship for the equipment and installations. General specification clauses shall apply where appropriate except where particularly redefined in the Special Specification Clauses.

3.1 Equipment Selection

The general basic requirements for design and selection of equipment shall be for

- Safety of Personnel and Equipment
- Adequate Operational Reliability
- Ease of Installation, Operations and Parts
- Interchangeability of Equipment and parts
- Robust and Economical Design

The offered equipment shall be brand new with state of the art technology and proven field track record. No prototype equipment shall be offered.

Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 15 years from the date of supply.

Vendor shall give a notice of at least one year to the end user/owner of equipment before phasing out the product/spares to enable the end user for replacement of order for spares and services.

3.2 CODES AND STANDARDS

The electrical equipment and complete installation offered shall comply with the relevant Indian Standards/Codes of Practices, this specifications, statutory regulations and sound engineering practices.

The complete system shall conform to the latest revisions of the following.

- The Indian Electricity Act & Rules
- The Indian Electricity (Supply) Act, 1948
- Regulations laid down by local statutory authorities and CEA/Electrical Inspectorate.
- The requirement of State Electricity Board/ Electricity Regulation Committee.
- Fire advisory Committee Insurance Act/Fire Insurance Regulations
- Indian Petroleum rules and any other regulations laid down by the Chief Controller of Explosives
- The factory act and any other regulations laid down by factory inspectorate

3.2.1 Obtaining approvals on behalf of Client from statutory authorities for materials, plant design/ drawings and complete installation shall be the responsibility of the contractor including all required liasoning (All statutory fees shall be paid by client). The contractor shall get the drawings, layouts of HV sub station, Genset (Diesel/Gas operated etc.) etc. approved from local electric supply company and Chief Electrical Inspector, as applicable. The contractor also shall arrange to get the installation inspected by CEI and carryout modifications/rectification as required by CEI, prior to commissioning of substation/electrical equipment.

3.2.2 Wherever Indian Standards do not exist, the relevant IEC, British or German (VDE)/IEEE/ NEMA standards shall apply. Any other Standard which is considered equivalent to or superior than

applicable Indian Standards may also be acceptable. The tenderer however, shall have to substantiate equivalence or superiority.

3.3 Voltage Regulation

During starting of heavy equipment, the voltage may drop by a maximum of 15% for period of up to 45-60 seconds depending upon the duty of the driving equipment and maximum 5% at the load terminal during running condition. All the electrical equipment shall, therefore, be suitable for trouble free and uninterrupted operation even during such voltage variation at the time of starting of heavy equipment.

3.4 Site/Ambient Conditions

All electrical equipment and installation shall be designed for the tropical climatic conditions and be suitable continuous operation under the site conditions as described below for design purpose.

Maximum Ambient Temperature	:	50 ^{0}C
Minimum Ambient Temperature	:	5 ^{0}C
Design Ambient temperature	:	**50 ^{0}C (unless otherwise specified for specific components/equipment)**
Relative Humidity	:	94%
Climate	:	Tropical, Dusty, Corrosive

If not specifically mentioned, an altitude not exceeding 1000m above mean sea level shall be taken into consideration for design purpose.

Where the equipment is installed outside and exposed to direct sunrise, these shall be suitable for operation at higher ambient temperature and rigorous weather conditions under which they are required to operate.

3.5 Design Basis

The distribution system shall be designed in accordance with project specifications and shall ensure continuity/reliability of supply, flexibility of operation and safety.

All components of the Electrical System shall be sized to suit the maximum load under the most severe operating conditions. Accordingly, the maximum simultaneous consumption of power, required by continuously operating loads shall be considered and additional margin shall be taken into account for intermittent service loads, if any.

The basic design data to be considered as follows.

Incoming Supply Conditions	11kV ± 10%
Frequency	50 Hz ± 5%
Voltage and Frequency Combined variation	± 10%
Fault Level at 11 kV	500 MVA symmetrical (1 second) or higher as per system requirement/power supply company requirement.
System Grounding	Solidly earthed
Fault Level at 415V (Design)	50kA symmetrical (1 second) or higher as per fault level requirement,

Control Circuit Voltage	LV panels: 230V AC via control voltage/constant voltage transformer HV panels up to 4 breakers: Power pack suitable for number of operations as per specifications. HV panels with 5 or more breakers: 110V DC, 100 AH (minimum or higher as required) for HV panel via battery and battery charger with DCDB with battery backup of minimum 2 hours.
HV Cabling	3C XLPE,11 kV (E) Aluminium, armoured, extruded inner sheath.
LV Cabling	Alu. multistrand conductor XLPE/PVC insulated, extruded inner sheath cable except for motor upto and including 3.7kW for which to use 3C x 2.5 sq mm, Cu multistrand conductor, XLPE/PVC insulated cables subject to voltage drop within specified limits. Cables having Aluminium conductor shall not be less than 6 sq mm.
Control/LCS Ammeter Cables	Multicore 1.5/2.5 sq mm Cu stranded conductor, XLPE/ PVC
LDB to Switch Board and Power Sockets	Multistrand Copper flexible, 2C, minimum 2.5 sq. mm for switchboard and 4 sq. mm of power socket or higher as per requirement
Earthing	Earth pit: Maintenance free Cu plate/GI pipe electrode (Chemical type) as per IS: 3043/specifications and with Copper strip/hot dip galvanized strip.
Induction Motor	Squirrel cage induction motor, TEFC, IP 55, continuous duty (S1) rating and S4 rating for Crane/ Hoist applications, class F insulation with temperature rise limited to class B, energy efficient design of IE3 class as per IS: 12615 (2018)/IEC:60034 amended up to date. However, motors operating with VFD shall be totally compliant and shall have vacuum impregnated, double insulation winding with Class H insulation and with temperature rise limited to class F of inverter duty
LV Panel Design (PCC/PMCC/MCC)	Fuse less design shall be used as per CPWD guidelines/specifications. Incomer rating of LV panel shall be with minimum 20% margin over maximum working load. ACB/VFD/Soft starter cubicles shall be in single front execution only. VFD panel shall be stand alone panel or as mentioned in specifications. The derated current of VFD/Soft starter for 50 ^{0}C continuous operating temperature shall be equal to or greater than 110% of the full load current as specified in IS: 12615 for squirrel cage induction motors or such type for dry well type pump set. For submersible pumps/DC or special motors the full load current shall be considered as per declared current by submersible pump/ equipment manufacturer. All PMCC/MCC feeders including motor starter feeders shall be 3 phase, 4 wire system with busbar and feeder MCB/MCCB/ACB to be TPN/4P.
Soft Starter	DOL starting, soft starter derated current for 50 ^{0}C operating conditions $\geq$ minimum 110% of rated motor current, with in-built or external bypass contactor, with in-line contactor and semi-conductor (fast acting) fuse protection, required protection parameters etc. Soft Starter shall be with inbuilt RS 485 and door mounted display unit.
Variable Frequency Drive (VFD)	VFD de-rated current for 50 ^{0}C operating conditions $\geq$ minimum 110% of full load current of motor as specified in IS: 12615, with in-line contactor and semi-conductor (fast acting) fuse protection, required protection parameters etc. VFD shall be with inbuilt RS 485 and door mounted display unit.

Starting current for various types of starter application to be considered for design	DOL starter: Minimum 6 times the full load rated current. Star-Delta starter: Minimum 3.5 times full load rated current Soft starter: Minimum 3.5 times or higher full load rated current VFD Starter: Minimum 2 times or higher full load rated current
Load Factor	Main motors/process equipment/blower: 0.9, Auxiliary load (valve actuators, crane/hoist etc.): 0.4 & Lighting load: 1.0
Diversity Factor	Main motors/process equipment/blower: 1.0, Auxiliary load (valve actuators, crane/hoist etc.): 1.1 & Lighting load: 1.1
DG Set	DG set and alternator rating shall be designed as per guidelines given in technical specifications. Further in case of DG set rating exceeding 1000kVA, DG sets shall be minimum 2 Nos. i.e 2 x 50% capacity as a minimum or such mutliples along with AMF cum load sharing synchronizing panel. Additional 10% contingency shall be considered over and above the load requirement.

Note: The Bidder shall be responsible for assessing the voltage level requirement as per local supply regulations and based on their load requirement and in case of voltage level other than 11kV is required or envisaged as per local power supply company norms/local regulations. The Bidder shall be responsible to consider the same and all HV equipment (GOD structure, HV breaker panel, transformer incomer voltage level etc. as applicable) shall be provided suitable for this revised voltage level without any cost implication and shall be meeting all statutory requirements and all fault level and other design requirements, all clearances, safety requirement, accessories etc. shall be as per IS/CPWD/CEA guidelines.

3.6 Power is expected through Double circuit 11kV overhead line from the local power supply company to be terminated in proposed new plant's Two/Four pole Structure with DO type HV isolator, fuses and lightening arrestors or at Power Supply Company breaker cum metering panel as applicable. Power is then transmitted through cables buried underground and terminated to the indoor 11kV switch gear board located in substation. Bidder to also refer the requiremetns specified elsewhere in tender (scope opf work / chapter 01 to 03 of Vol. 2 / BOQ as applicable).
In case of existing HV power at site, same shall be strengthened for additional demand for onward distribution of power from this point by bidder and shall also include required modifications in existing switch yard and provision of required additional two/four pole structures shall be provided to meet the statutory and design requirements and then conveyed to two pole structure of proposed plant and onwards to incomer of HV panel or to HT side of transformers as per requirement. The entire onwards power distribution from the supply company panel / GOD structure including required step up/down of voltage levels shall be in bidder's scope.

3.7 The HV switchgear shall comprise of Vacuum Circuit Breakers with required incoming and outgoing and shall feed proposed nos. of transformers of adequate rating for the proposed plant installed outdoor. The proposed transformers are connected by cables/bus ducts to the Main 415V power (cum motor) control centre (PCC/PMCC) at sub station building. This PCC/ PMCC shall in turn feed down stream MCC and PDB/MLDBs etc. for feeding various loads. The HT side of transformers shall be fed from outgoing of HT Breaker panel or in the case where transformer ratings are lower and within the limit as permitted by electrical inspector / statutory requirement (generally with single transformer rating of 400kVA or lower and for total / combined transformer rating within the substation of 800 kVA or below and as per latest prevailing rules/ guidelines of electrical inspector / power supply ompnay / statutory authority) direct from two / four pole structure.

3.8 The motors shall be suitable for outdoor installation with tropical insulation and weather proof to IP 55 as a minimum. All motors shall be started and stopped by push buttons at Local Control Stations located near respective motors. Starters shall be housed in PMCCs/MCCs with START/ STOP (Mushroom head stay put type with padlocking facility)/OVERLOAD reset push button and Auto-Off-Manual, local-remote selector switches. Motors of rating less than 7.5kW rating shall be provided with Direct-On-Line starting provision, motors of rating 7.5kW and above and less than 75kW rating shall be provided with fully automatic Star/Delta starters and motors rated 75kW and above shall be provided with soft starters unless specifically mentioned to operate with alternative menthods like VFD etc. as per process/operational requirement. Motors shall be energy efficient as per IE3 class as minimum. Motors when installed outdoor, shall be provided with FRP canopy of minimum 2mm thick.

3.9 Power, control & earthing cables to be laid in cable tray for indoor area and to be laid on overhead cable trays (min. 3m clear height and for road crossing shall be min. 4.5m clear height) or in cable trench for outdoor area. **For outdoor area, cables laid direct buried in ground are not permitted**.In indoor areas, cables shall be laid in trenches through medium duty GI cable trays (minimum 610 g/m^2 galvanizing as per IS: 2629). Cables shall be so selected that voltage drop from PMCC/MCC to consumer end/upto motor does not exceed **5%** and subject to overall voltage drop from transformer outgoing/source to consumer end/motor shall not exceed **6%**. Accordingly the voltage drop for main power cables (feeding PMCC/PCC or feeding MCC) shall be generally sized for voltage drop not exceeding **0.5-1%** to meet the permissible overall voltage drop requirement of **6%**. Cables having Aluminium conductor shall not be less than 6 sq mm.

Cables shall be sized based on the rating of the transformer for PCC/PMCC, based rating of incomer ACB/MCCB for MCC, based on maximum continuous rated load current for outgoing feeder, after suitable derating within 10% overload capacity after derating and the voltage drop. The derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, resistance @ 70 ^{0}C maximum permissible temperature rise for cables, etc. shall be taken into account. The derated cable current shall be at least 10% higher over the rated load current. A **derating factor of 0.65** shall be used as a minimum or higher as per site conditions. Vendor will have to submit the calculations for the same.

3.10 Sub-Station/MCC Room

Sub-station or MCC room, wherever required shall be located in a safe area close to load centre. The building shall be sized to take care of present and future needs and to maintain adequate clearances between equipment for ease of maintenance. Clearance around equipment shall be maintained as per IE rules and equipment supplier's recommendations, whichever is higher. The recommended minimum clearances shall be as follows.

a) Front clearance for LV switch board panels	Sinlge row of SWBD: 1500mm Two rows of SWBD: 1800-2000mm between two row of panels
b) Front clearance for HV switch board panels from wall	Minimum 2200mm or higher
c) Rear clearance for panels requiring maintenance from rear	1000mm from the outermost edge of panel to any wall/obstruction/ projection of column
d) Rear clearance for panels not requiring back access/maintenance from rear	150-200mm
e) Side clearance from wall	750-1000mm
f) Clearance between two panels	Equal to the depth of panel

If battery banks are required/provided, same shall be located in a separate adequately ventilated room along with necessary exhaust system and water connection with sink. Floor of battery room and walls upto 1.0m height shall have acid/alkali resistant protective material coating/tiling.

Adequate safety equipment such as insulating mats, exit signs, shock/fire hazard charts, warning signs, first aid boxes, portable fire extinguishers etc. shall be provided in sub-station/MCC room as per statutory regulations.

3.11 Earthing system design and installation shall be generally as per IS: 3043. Earthing system shall be carried out by hot dip galvanized MS/Copper strips, electrodes by Copper/GI pipes. All earthing pits shall be maintenance free chemical type earthing pits with inner pipe minimum 40 mm dia. having 200-250 micron galvanising or Copper coated solid steel road/flat strip type connection terminal 14mm dia with constant ohmic value surrounded by highly conductive corrosion resistant chemical compound with high charge dissipation suitable for electrical installation like transformers, DGs, lightning arresters, transformer neutrals, AC plant, Instrument control panels and sensitive computer system (like Automation, SCADA) with 3meter length of pipe with two nos. 25kg bag of back filling compound (earth enhancement material). All equipment shall have two separate and distinct earth points. Earth resistance shall not exceed one ohm at any point.

3.12 Suitable rating automatic power factor improvement panel with integral capacitor bank shall be designed/provided at each main bus to improve and maintain lagging power factor of **0.99 or better** (maximum 1.0, leading power factor is not permissible) at incomer of main LV panel. Capacitors shall be considered for VFD motor load also to improve power factor to 0.99. **Under no circumstance, the power factor shall be less than 0.96 lag at HV side/power supply company meter.**

Voltage and current harmonics at supply side of drive system at PCC (point of common coupling) shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations of the IEEE 519 2014 or latest edition.

Drive manufacturer shall provide necessary passive/active harmonic filter solution at point of coupling to comply with standards as specified above to limit total harmonic distortion (THD). However for turbo blowers with VFD the passive filter solution shall be provided along with blower for blower VFD installed within blower skid/blower panel. Passive filter shall be preferably of the same make as VFD or shall be as recommended and vetted by VFD manufacturer.

3.13 Adequate numbers of small and welding power outlets to be provided at appropriate places. Appropriate numbers of Welding receptacles shall be provided at suitable locations such that it ensures accessibility with 50meter length of trailing cable at any point within battery limits of the plant. The welding receptacles shall be industrial heavy duty type rated for 415V, 63A, 5 pin, 3 phase, 4 wire system complete with scraping earthing facilities, necessary interlocks and associated plugs. Housing shall be of Polycarbonate. The receptacles shall be weatherproof type and additionally flameproof type for hazardous areas.

3.14 Lighting design shall conform to relevant international codes and standards, IES hand book and shall take into consideration the requirements from point of view of safety and ease in operation & maintenance. A maintenance factor of 0.8 shall be assumed for lighting illumination level calculations for normal areas. Co-efficient of utilization shall be calculated as per fixture type and areas. It shall be the Bidder's responsibility to demonstrate the illumination levels as specified in these specifications elsewhere using lux meter and rectify by providing additional lighting fixtures, if necessary, in case if illuminations levels are found to be below the specified levels. Dark patches and uneven illumination shall be avoided. **Indoor and Outdoor lighting shall be carried out by LED light fittings.**

3.15 Drawings/Documents

Execution Drawings/Documents

Following detailed design drawings/documents are to be prepared in line with recommended specifications/details and submitted to Engineer-in-charge in a timely manner to allow for review and approval as a minimum.

a) List of Drives/Loads with Quantity (Working, Standby and Total)/Rating/Type of Starter/ Specifications along with Power Load Statement
b) Transformer, DG Set, Capacitor Sizing Calculations and Fault Level Calculations
c) SLD, Power and Control Diagram of Complete Electrical System
d) Wiring/Schematic Drawings for Complete Electrical System (HV Panels, LV Panels, LVDB, Lighting Panels, PDBs etc.)
e) Overall Cable Layout and Unit Wise Cable Tray Layout
f) Earthing Layout with Earthing Calculations
g) Transformer & DG foundation Drawings, Substation Layout Drawings with Fencing Details
h) Equipment Layout Drawings
i) Internal Lighting Layout with Calculations
j) External Lighting Layout
k) Cable Schedule with Voltage Drop Calculation/Sizing Calculations
l) Interconnection Schedule
m) GA Drawings for All Equipment including Sectional Drawings wherever necessary and specifying Recommended Installation, Weight and Clearance Requirements etc.
n) Filled in Data Sheets
o) Schedule of Quantities along with Brief Specifications
p) Design/Sizing Calculations for Equipment as Applicable
q) O and M manual for All Equipment

As-Built Drawings/Documents

All above final documents and drawings incorporating modifications, if any, done during erection/commissioning shall be furnished in number of sets as specified in scope of work.

3.16 HV Supply

The Contractor shall ascertain the details of availability of HV supply from local electric supply company as applicable for site location wherever HV supply is to be availed and procure the equipment accordingly. It is the responsibility of the Bidder to liaison and complete the formalities of procuring power from Power Supply Company/Utility/Discom. The Client shall pay the charges for obtaining the above connection whereas necessary liaison for the same shall be done by the Bidder/Contractor in consultation with Engineer-in-charge.

3.17 Condition of Operation

The equipment offered shall be suitable for continuous operations under high ambient temperature of 50 ^{0}C, which shall also be considered as design temperature for selection/sizing of equipment, unless otherwise specified.

All electrical equipment installed in hazardous areas, where applicable, shall be selected as per IS: 5571 and DGMS regulations, where applicable, and shall meet the requirements of relevant IS, IEC or NEC standards. Area classification drawings shall be prepared by the Contractor indicating the zone of hazardous area and the gas group. A hazard source list shall be prepared by the Contractor including the list of all flammable materials handled along with their properties like flash point, ignition temperature, explosive limits etc. Motors for digester mixing and within

hazardous area shall be weather and explosion proof suitable for the hazard class. Electrical equipment for hazardous areas shall have test certificates issued by recognized independent test house (CMRI/BASEEFA/UL/FM or equivalent) and have valid statutory approvals as applicable for specified locations.

The Contractor shall submit layout drawings, showing the location of switch board and other equipment proposed to be installed for the approval of Engineer-in-charge.

3.18 Standards and Codes

- Applicable standards govern the materials and workmanship in the manufacture of all Equipment/ items of Electrical Equipment.

Codes	Description
IS: 731, BS 137, IEC 383	Pin & Disc Insulator
IS: 2544, IS: 5350, BS 3297, IEC 168	Porcelain post insulators for systems with nominal voltage greater than 1000V
IS: 5621	Hollow insulators for use in electrical equipment
IS: 398 Part I and II (1996)	ACSR conductor
IS: 9920 Part 1 to 4 (2002)	Specification for High Voltage Switches for rated voltage above 1kV and less than 52kV (First Revision)
IS: 9921	Alternating current disconnectors (isolators) and earthing switches for voltages above 1000V
IS: 9385 (1983)	Governing specifications for GOAB switch
IS: 3070	Lighting arresters for alternating current systems
IS: 15086	Surge arresters
IS: 8828	Electrical Accessories -Circuit Breakers for Over Current Protection for Household and Similar Installations
IEC 60529	Enclosure degree of protection IP 5X
IS: 3231	Electrical relays for power system protection
IS: 4047, IEC 408	Air Break Switches
IS: 2208, IEC 259-1	Fuses
IS: 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2419	Dimensions for panel mounted indicating and recording electrical instruments
IS: 2705	Current transformers
IS: 3156	Voltage transformers
IS: 2026, IEC 60076	Power transformers
IS: 11171	Specification for Dry-Type Power Transformers.
IS: 335	New insulating oils
IS: 1180 Part 1 (2021)	Outdoor Type Oil Immersed Distribution Transformers Up to and including 2500kVA, 33kV Specification
IS: 8468	On-load tap changers
IS: 2099	Bushings for alternating voltages above 1000V

IS: 6600	Guide for loading of oil immersed transformers
IS: 4237	Switchgear General Requirements
IS: 13947 IEC 60947-1 and IEC 60947-2	Low-voltage switchgear and control gear
IS: 375	Panel Wiring
IS: 3427	AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1kV and Up to and Including 52kV
IS: 2516	Moulded Case Circuit Breakers
IS: 3842	Application guide for electrical relays for ac systems
IS: 13925	Shunt capacitors for ac power systems having a rated voltage above 1000 V
IEC 60831 (1 and 2)	Shunt capacitor of the self- healing type for AC systems having rated voltage up-to and including 1000V
IEC 61921	Power capacitors –Low voltage power factor correction banks
IS: 16636	Automatic Power Factor Correction (APFC panels for voltage rating up to and including 1000V)
IS: 2959, IEC 158-1	Contactors
IS: 1822, IEC 292	Starters
EN 50081-1, 50082-2 and 60204-1	Microprocessor Soft Starter
IEC 61800 and/or IEEE 519	Harmonics Control & Reactive Compensation Of Static Power Converters
IEC 721-3-3, Class 3C1	Maximum Corrosion Level of the Cooling Air
IEC 721-3-3 Class 3C2	Maximum Corrosion Level of the Chemical Gases
UL 508C	Solid state thermal protection of AC Drive
IS: 722	Specification for AC Electricity Meters
IS: 12615 (2018)	Energy efficient induction motors-three phase squirrel cage
IS: 15999 (Part 1)	Rotating electrical machines: Part 1 Rating and performance
IS: 15999 (Part 2)	Rotating electrical machines: Part 2 Method of tests, standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)
IS: 12065	Permissible limits of noise level for rotating electrical machines
IS: 2253	Designation types of construction and mounting arrangement of rotating electrical machines
IS: 8789	Values of performance characteristics for three phase induction motors
IS: 9283	Motors for submersible pump sets
IS: 9334	Electric motor operated actuators
IS 8130	Conductors for insulated electric cables and flexible cords
IEC 228	Conductors of Insulated Cables
IEC 230	Impulse tests on cables and their accessories
IEC 502	Extruded solid dielectric-insulated power cables for rated voltage from 1kV up to 30kV.
IEC 540	Test methods for insulations and sheaths of electric cables and chords
IEC 229	Test on cable over sheaths which have special protective functions and are applied by extrusion.

IEC 287	Calculations of continuous current rating of cables (100% load factor).
IEC 60751	Industrial platinum resistance thermometers and platinum temperature sensors
IEC 61537	Cable management -Cable tray systems and cable ladder systems
IS: 1554 Part1	PVC insulated (heavy duty) LT electric cables up to 1.1kV
IS: 7098 Part I	XLPE Insulated LT Electric cables (heavy duty) up to 1.1kV
IS: 7098 Part II	XLPE insulated PVC sheathed cable for voltage from 3.3kV up to 33kV
IS: 5831 (1984)	PVC insulation & sheath of electrical cables
IS: 694	PVC Insulated cables for working voltage up to and including 1100 V
IS: 1255	Code of practice for installation and maintenance of power cables up to and including 33kV rating
IS: 3975	Mild steel wires, formed wires and tapes for armouring of cables
IEC 885(2) – 1987 Part-I)	Electrical test methods for electric cables partial discharge test
IS: 10810	Methods of test for cables
IEC 811	Common test methods for insulating and sheathing materials of electric cables
IEC 230	Impulse test on cables & other accessories
IEC 859	Cable termination for gas insulated switchgear
IS: 3961	Recommended current ratings for cables
IS: 3043	Code of practice for earthing
IS: 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS: 2633	Methods for testing uniformity of coating of zinc coated articles
IS: 1897	Copper strip for electrical purposes – Specification
IS: 2309	Code of practice for protection of buildings and allied structures against lightning
IS: 732	Code of practice for electrical wiring installations
IS: 1646	Code of practice for fire safety of buildings (General) Electrical installation
IS: 2509	Rigid non-metallic conduits for electrical wiring
IS: 6946	Flexible (Pliable) non-metallic conduits for electrical installation
IS: 9537	Conduits for electrical installations
IS: 3854	Switches for domestic purpose
IS : 3415	Fittings for rigid non-metallic conduits
IS: 3837	Accessories for rigid steel conduits for electrical wiring
IS: 14927	Cable trunking and ducting systems for electrical installation
IS: 4648	Guide for electrical layout in residential building Indian electricity act and rules
IS: 1293	3 pin plugs and sockets
IS: 4795	Holders for Indicator Lamps for Electronic and Telecommunication Equipment
IS: 3646	Code of practice for interior illumination
IS: 1913	1969 General and Safety requirements for Electric lighting fittings
IS: 1239, IS: 2713	GI Lighting Poles

IS: 1944	Code of practice for lighting of public thoroughfare
IS: 374	Electric ceiling type fans and regulators
IS: 1293	Plugs and socket-outlets of rated voltage up to and including 250 volts and rated current up to 16 amperes – Specification
IS: 6665	Code of practice for industrial lighting
IS: 8224	Electric lighting fittings for division 2 areas
IS: 9583	Emergency lighting units
IS: 9974	High pressure sodium vapour lamps
IEC 62305	Protection against lightning -Part 4: Electrical and electronic systems within structures
IS: 1271	Thermal evaluation and classification of electrical insulation
IS: 1544	Cotton calico
IS: 1868	Anodic Coatings on Alluminium and its Alloys – Specification
IS: 2190	Selection, Installation and Maintenance of First-aid Fire Extinguishers — code of practice
IS: 2546	Specification for galvanized mild steel fire bucket
IS: 5572	Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installation
IS: 9677	Guide for limits of temperature-rise of the windings of electrical equipment when tested by different methods
IS: 9678	Methods of measuring temperature rise of electrical equipment
IS: 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
IS: 15652	Insulating mats for electrical purposes – Specification
IS: 5424	Rubber mat
IS: 4770	Rubber Gloves -Electrical Purposes – Specification
IS: 2551	Danger notice plates
ISO 3046	Diesel Engine
IS: 4722, BS 2613	Alternator
IS: 16101	General lighting LED and LED modules
IS: 16102 (Part 1)	Self ballasted LED lamps for general lighting service-Safety Requirement
IS: 16102 (Part 2)	Self ballasted LED lamps for general lighting service-Performance Requirement
IS: 16103 (Part 1)	LED modules for General lighting-Safety Requirement
IS: 16103 (Part 2)	LED modules for General lighting-Performance Requirement
IS: 16107 (Part-10)	Luminaries Performance-General Requirement
IS: 16108	Photo biological safety of lamps and lamp systems
IS: 10601	Dimensions of terminals of HV switchgear and control gear
IS: 12729	General requirements of switchgear and control gear for voltages exceeding 1000V
IEC 1330	High voltage/low voltage prefabricated substations
IEC 60694	Common clauses for MV switchgear standards

Bidders' stamp & initials

IEC 6081	Monitoring and control
IS: 8686	Specification for static protective relays
IEC 376	Filling of SF6 gas in RMU

- Use the latest issue of Standards. All revisions/ammendments issued in any and all standards shall automatically apply.
- It is essential that the electrical power distribution system will comply in all respects with the relevant statutory and regulatory instruments of state of Gujarat/as applicable state and that of India.
- The relevant, state and national, statutory and regulatory instruments for electrical installations are, The Indian Electricity Rules 1956, The Electricity Act 2003, CEA regulations, State Electricity Act 2003, ECBC (Energy conservation & building code), fire prevention and life safety measurement act 2013.

Safety and Security

- The design should include all reasonable precautions and provisions for the safety of operating and maintenance personnel.
- Electrical works design life shall be Minimum 15 years.

4.0 EQUIPMENT/TECHNICAL SPECIFICATIONS

All equipment shall be new and supplied by the reputed and approved manufacturers' only. All equipment shall be complete with all necessary weather and anticorrosion protection including tropicalization to prevent damage due to climate, harsh atmosphere, dust and corrosive vapours.

Certain minimum requirement for the major equipments shall be as follows.

❖ 11kV SWITCHYARD (TWO POLE/FOUR POLE STEEL STRUCTURE)

Two pole structures shall be erected in switchyard to receive 11 kV power supply from power supply company (DISCOM) with following minimum equipment.

a) 11 kV MS pole structure with ISMB, ISMC, hardware etc. including grouting of MS poles in RCC grout blocks/foundation works.
b) Vertical 150 mm dia. GI pipe for cable support.
c) Chain links fencing with gate.

The minimum Factor of Safety for supports shall be as per CEA (Measures relating to Safety and Electricity Supply), Regulations as and when these are notified by the authority. The supports shall be suitable for the wind loads as per relevant IS.

Following equipment/accessories shall be required for each 11 kV two pole structure as minimum and other as per drawings/statutory requirements at site shall be provided. All required sub assemblies and accessories shall be suitable for environmental and atmospheric conditions as well as pollution levels of the location(s) where such switchyards are to be built. For locations where pollution levels are high or for critical locations anti-fog type insulators are to be used invariably.

Sr. No.	Particulars	Quantity
1	11kV Porcelain glazed disc insulator with hardware/polymer composite insulators.	3 Nos.

2	11kV, 10kA single pole gapless lightning arrestor (LA) with all required fitting accessories/hardware. LA shall be with surge counter and monitor.	3 Nos.
3	11kV, 9kV LA clamp with nut bolt.	3 Set
4	11kV, 10kV LA jumper wire.	3 Nos.
5	11kV, 400A, 3 pole gang operated air break (GOAB) heavy duty switch with gang operated mechanism & earth switch and all required fitting accessories/hardware. Insulators shall be as per expected environmental and pollution conditions.	3 Nos.
6	11kV, DO fuse assemblies with 400A fuse element with fuse barrel, fiber barrel insulated operating rod and all required fitting accessories/hardware.	3 Nos.
7	11kV, 10kA insulator for 11 kV GOAB switch, DO fuse etc. porcelain glazed disc insulator with hardware/polymer composite insulators.	15 Nos.
8	Fiber operating insulated rod with mechanism and handle suitable for 11 kV GOAB switch.	1 Set
9	ACSR (Mink/Dog/Panther) conductor with required clamps, connectors and hardware etc.	30 RMT or as actual
10	25mm X 6mm thick Copper earth strips in two parallel runs in required quantity i.e. from LA to earthing chambers.	As required
11	Required concrete foundation (grout blocks) etc.	Lot
12	Two/Four pole structure is to be painted with two coats of red oxide followed by two final coats of Alluminium paint as per IS, specifications and drawings.	Lot

Note: For ratings other than 11kV, equipment kV rating shall be changed to suit requirements as per system kV rating and all clearances, safety requirement, accessories etc. shall be as per IS/CPWD/CEA guidelines.

All members shall be fabricated to suit the mounting/fixing of GOD, LA, DOF, Disc/Pin/Post insulators, cable end termination kit/box etc. All members, nut-bolts, washer etc. used shall be hot dip galvanized.
All metallic supports shall be permanently and effectively earthed.
Earthing terminals shall be provided by welding 12mm size bolt/cleat of 50mm x 6mm size MS flat shall be fixed to each joist with a hole of 15mm dia. Fixing or joining of members shall be done by nuts and bolts. Suitable MS flat supports and cleats shall be fixed to ISMB poles for supporting/ fixing the earthing protection strip in the manner approved by the Client.
Vitreous enamelled caution boards or any other statutory requirements shall be provided in accordance with CEA (Measures relating to Safety and Electricity Supply).
Protective guards shall be used where overhead line crosses or is in proximity to any telecommunication line, or any other overhead lines, and in populated localities. Every guard wire shall be connected to earth wherever its electrical continuity is broken.
DP structure/accesorries shall meet all statutory requirement laid down in I. E. Act/CEA regulations.

Stucture

Pole structure shall be of rolled steel of minimum ISMB 150mm X 75mm size and minimum 9 meters in length with 400mm X 400mm X 6mm thick base plate welded at bottom end of the poles of structure.
Mild steel cross members of minimum ISMC 100mm X 50mm size channels of required length and numbers shall be provided with cross bracing angles ISA of 50mm X 50mm X 6mm size of required length.
Clamps, cleats etc. shall be fabricated from minimum 50mm X 6mm size MS flats as per actual requirement. All bolts, nuts, washers etc. shall be of minimum 15mm dia.
Welding at site should be avoided as far as possible. In case, welding becomes necessary, the joint shall be covered with cold galvanizing paint.
All MS parts shall be painted with two coats of red oxide followed by two coats of Aluminium paint. All MS part shall be hot dip galvanized as per IS: 2629. Alternatively All cross members and clamps shall be hot dip galvanised after fabrication.

11kV GOAB Switch

The GOAB switch shall be triple pole construction suitable for vertical/horizontal mounting. Each pole shall consist galvanized steel base, insulators, Copper alloy male and female contacts, arcing horns of adequate section to break magnetizing current of transformer, MS square coupling rod of adequate length for rocking operation, required length of GI pipe for operation from ground level and operating handle, for smooth operation. Jumper shall be EC grade braided Copper of appropriate size to complete the current path from moving post to fix post.
Disconnector and earthing switches, including their operating mechanism shall be designed such that they cannot come out of their open and closed positions by gravity, wind pressure, vibrations, reasonable shocks or accidental touching of the connecting rods of their operating mechanism.
Isolators shall be provided with provision of locking in open and closed positions. The switch shall be single throw-single break or single throw-double break.
The insulators shall be post type, high quality brown porcelain, highly glazed/polymer insulator and shall be of appropriate voltage rating, suitable for atmospheric conditions specified. Grading rings may be provided to obtain uniform voltage stress distribution, where required.
All poles of the switch shall be gang operated by a common operating mechanism such that all poles close or open simultaneously. The operating mechanism shall be positive type and shall be provided with two earthing terminals. Operating handle shall also be provided with an "equalizing braid" earth connection to prevent unequal potential between structure and rod during faults.

11kV Drop Out Fuse

The DO fuse assembly set shall be single pole construction suitable for 11 kV supply and suitable for vertical mounting. Each pole shall consist galvanized steel base, insulators, Copper alloy DO top and bottom contacts and fuse carrier top and bottom contacts, epoxy extruded fiber fuse carrier. The assembly shall be mounted on pole structure, complete with fuse elements of required ampere rating. The fuse link shall consist of iron channel base, stack insulator per phase, fuse carrier Bakelite tube, non-ferrous metal parts and spring loaded phosphor-bronze contacts. The insulator shall comply with impulse voltage test in accordance with relevant IS.

Technical Requirement for GOAB Switch and DO Fuse Set

Rated Voltage	12 kV
Rated Current for DO Fuse Set	250/400 Amp
Rated Current for GOAB Switch	400 Amp
Impulse Withstand Voltage to Earth	60 kV
Impulse Withstand Voltage Across the Terminals	75 kV
Power Frequency Withstand Voltage to Earth	28 kV
Power Frequency Withstand Voltage Across the Terminals	32 kV
Rated Short Time Current for 1 Second	10 kA

Lightning Arrestor

Lightning arrestor shall be for 11 kV rating furnished complete with insulating base and anchoring hardware for mounting on steel structure. The arrestors shall be metal oxide gapless type comprising of a stack of zinc oxide valve elements as per IS: 3070.
The arrestors shall be single phase, single pole suitable for outdoor installation under atmospheric conditions as specified elsewhere.
The arrestor shall have adequate thermal discharge capacity for severe switching surges, long duration surges and multiple strokes. Insulators shall be wet process porcelain, brown glazed and free from imperfection. All metal parts and hardware shall be hot dip galvanized.
Independent Copper earthing shall be provided for LA.

Technical Requirement for Lightning Arrestor

Rated Voltage	9 kV
Rated Current	400 Amp
Creepage Distance	Total: 300mm & Protected: 140mm
Type	Station Class
(1) 1 Minute Power Frequency Withstand Test Voltage (2) Impulse Withstand Test Voltage	28 kV 75 kV
Minimum prospective for 0.2 Second Symmetrical Fault Current	21.86 kA
(1) Top Connection Arrangement (2) Bottom Connection Arrangement	(1) ACSR Conductor (2) Hot dip galvanized strip/ galvanized stranded steel wire
Nominal Discharge Current	10 kA

Conductor

Aluminium conductor steel reinforced (ACSR) or equivalent all aluminium alloy conductors (AAAC), all aluminium conductor (AAC) as per site environmental and pollution conditions shall be used. ACSR shall be hard drawn from 99.5% pure electrolytic aluminium rods with 60% IACS conductivity. The vendor shall specify the conductivity. The aluminium shall have resistivity of 0.028264 Ω mm^2/m at 20 ^0C temperature. Thermal conductivity shall be 0.563 calories/cm/^0C and density shall be 2.703 gram/cm^3 shall be as per typical drawing and as per IS: 398.
The size of conductor shall depend upon the voltage regulation, factor of safety, power to be transmitted, length of line, line voltage and mechanical strength desired.
Suitable insulating paint shall be applied on bare conductors in coastal areas to prevent corrosion.

Stay Arrangement

To prevent tilting of a pole from its normal position due to abnormal wind pressure and deviation of alignment, the pole shall be kept in position by stays.
Galvanized iron stay wires and stay rods of adequate size shall be used. The individual wire used to form "stranded stay-wire" shall have minimum tensile strength complying with relevant IS. For double pole structure, for stays along the line, two in each direction or as required depending on the angle of deviation shall be provided.
When two or more stays are provided on the same pole, each stay shall be grouted entirely separate from the other.
The angle between the pole and stay wire shall be about 45 degree and in no case it shall be less the 30 degree.
Stays shall be anchored either by providing base plates, iron angle or rail.
Stay wires shall be connected to the pole with a Porcelain Guy Strain Insulator. The standard guy strain insulators shall be as per relevant IS. The porcelain insulator shall be inserted in the stay wire at a height of minimum 3 meter vertically above the ground level. The strain insulators shall be free from defects, thoroughly vitrified and smoothly glazed.
Wooden insulators shall not be used for stay/guy wire.

- **11kV HV SWITCH GEAR (VCB) PANEL**

Design Criteria

The switchgear system shall be capable of continuous operation at specified rating under the design conditions specified here in.

The switchgears will be located indoor/outdoor area as per requirement.
The de-rating of complete panel including bus bar section shall be done at **50 ^{0}C ambient design temperature** if it is designed at lower ambient temperature. The maximum temperature in any part of the equipment at specified rating shall not exceed 85 ^{0}C.
Applicable standards for HV panels shall be, IEC 62271/100-200, IEEE 1584, IEC 60947, IEC 60439, IS: 13118-191.

Specific Requirements

The switchgear shall be metal-clad, extensible on both sides, floor mounted, draw-out type with fuse-less design and suitable for Local/Remote operation (Both control and monitoring). Enclosure shall conform to the degree of protection IP 4X and IP 5X for metering section.
The minimum thickness of sheet steel used shall be 2mm CRCA steel/Al Zn and gland plate of 3mm thick.
The switch gear assembly shall comprise continuous, dead-front, line-up of free standing, vertical cubicles.
Each cubicle shall have front hinged door with latches and removable back cover. All covers and doors shall be provided with recessed neoprene gaskets. All doors shall have pad locking arrangement. The swing of the door shall be more than 90 degree.
The design shall be such that failure of one equipment shall not affect the adjacent units.
Each cubicle shall be separated from adjacent one, by grounded sheet steel barrier and bus sealing arrangement.
All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on control cabinet built on the front of the cubicle.
Each breaker shall be provided with 6 way, 3 position, spring return to neutral, angular movement, Trip-Neutral-Close (TNC) switch with lockable pistol grip type handle.
Each breaker shall be provided with 4 way, 2 position, angular movement with lever type handle Local-Remote selector switch.
Each switchgear cubicle shall be provided with thermostat controlled space heater and 3 pin 15 Amp plug point and light point operated at 230V 50 Hz AC.
Bus connections from bus compartment to breaker compartment, breaker compartment to cable compartment, and bus compartment to adjacent panels shall be through sealed resin cast bushing assembly.
Each breaker cubicle shall be provided with 'service' and 'test' position limit switches having at least 4 NO and 4 NC contacts. The swing of the door shall be more than 90 degree.

Bus and Bus Taps

Bus bars shall be of uniform cross section throughout the entire length of panel and suitable for carrying rated current continuously and short circuit current for specified duration without overheating.
The main bus bar and connections shall be of high conductivity Copper. **Copper bus bars shall be sized for maximum 1.4 A/mm^2 current density.**

All bus bars, jumper connection shall be fully insulated for working voltage with adequate phase /ground clearances and shall be sleeved with R,Y,B colour coded PVC heat shrinkable sleeves. Bus bars, links, live parts etc. shall have non-flammable epoxy cast-resin shrouds. All jointing hardware shall have nylon caps. No paper/cotton based insulation shall be used anywhere in the panel.
Safety shutter, phase barrier, bus bar seal-off bushing plate, support insulators etc. shall be of non-flammable high tracking fibre glass/epoxy insulation system.
All buses and connections shall be supported and braced to withstand dynamic electro-magnetic stresses due to maximum short circuit current and also to take care of any thermal expansion.

Circuit Breaker

Circuit breaker shall be triple pole, single throw, vacuum type, electrically operated (on/off), electrical draw out (EDO) type.
Circuit breaker shall have Service, Test and Disconnected (Isolated) positions with positive indication for each position.

Circuit breakers of identical rating shall be physically and electrically interchangeable.

Circuit breaker shall have manual spring charge as well as motor wound charging facility with mechanical and electrical anti-pumping features and shunt trip. Motor wound mechanism spring charging shall take place automatically after each breaker's closing operation. The motor shall be suitable for operation with voltage variation from 85% to 110% of rated voltage.
Mechanical safety interlock shall be provided to prevent following.

a) Circuit breaker from being raked in or out of the service position when the breaker is closed.
b) Raking in the circuit breaker unless the control plug is fully engaged.
c) Closing and opening of the breaker in an intermediate position between 'Service' and 'Test' and between 'Test' and 'Disconnected' position.

Automatic safety shutters shall be provided to fully cover the female primary contacts when the breaker is withdrawn from service position.
The manual trip device shall be located on the front door and indicators with shrouds will be visible from front door even when breaker is closed.

Each breaker shall be provided with following.

a) Auxiliary switch with 6 NO + 6 NC contacts, mounted on the draw-out portion of the switchgear.
b) Position/cell switch with minimum 3 NO + 1 NC contacts, one each for Test and Service position.
c) Auxiliary switch, with 4 NO + 4 NC contacts, mounted on the stationary portion of the switchgear and operated mechanically by a sliding lever from the breaker in Service position.
d) Trip push button, mechanical ON-OFF indication, operation counter and mechanism charge/ discharge indicator.

Limit/auxiliary switches and shall be convertible type i.e. facility for changing NO contact to NC and vice-versa. Switch contact shall be rated 10 A AC and 2A DC at operating voltage.

Each breaker shall be provided with suitable encased rollers.
The trip coils shall be operated satisfactorily at voltage between 70% and 110% of rated control supply voltage.

Each circuit breaker cubicle shall be provided with earthing facility. Earthing facilities shall be fully interlocked to prevent faulty operation e.g. earthing of live parts.
One set of earthing truck for cable earthing and bus earthing shall be supplied along with panel.
For each breaker feeder following DI and DO shall be considered.

DI
Breaker ON
Breaker Trip
Breaker Test Position
Breaker Service Position
DC Fail
Local/Remote Selection
Vibration Sensor Feedback: 6 Nos. (if applicable for motor feeder)

DO
Breaker On
Breaker OFF

RTD Input

Winding and Bearing Temperature: 8 Nos (if applicable for motor feeder)

Protection and Measurement

Protective Scheme Requirement

Main protective relay shall be microprocessor based, current and voltage based/monitoring numerical relays with combined protections and with communication facility as listed in the table given below. Relay shall have minimum 5 logic input and output each, with fault (Minimum 10) and event record (Minimum 100). Front USB port for local downloading of fault, event records.
Auxiliary relays, timers switches etc. required to make the scheme complete shall be considered as part of the scope of work.
All CT-PT wires shall be brought to test terminal blocks before connecting to circuits.
The circuits of various protections shall be connected to master trip relays though auxiliary relays (flag indicated).
Auxiliary relays shall be provided for each transformer fault. Connection of the relay shall be through links to facilitate maintenance.
For control supply distribution, panel to panel, separate set of terminal blocks shall be provided. All items/accessories required for above in each panel and in incoming panels shall be provided by the supplier.
All relays shall be self/hand-reset type with digital/flag indication. NO/NC contacts for relays shall be as per requirement of approved protection, annunciation and interlock schemes. Wherever required, Vendor/Supplier shall provide auxiliary relays for contact multiplication.
Annunciation facia shall be mounted on the panel and details shall be finalized during drawing approval stage.
Emergency stay-put type off push button/mechanism are to be considered.
DC supply fails alarm and indication is to be considered.
Draw-out type line PTs, shall be provided on all incomers with suitable 110V AC secondary two winding transformer for metering and protection separately of minimum burden 100/200 VA or higher as required.

Incomer of HV breaker shall be with following as a minimum.

Sr. No.	Relay	Indication and Monitoring	Digital Type Meter
1	PT Fuse Failure Relay	Phase Indication (R, Y ,B)	PF Meter & Ammeter and ASS
2	Numerical Relay with RS 485 Communication with Combined Protection with Configurable Digital Input and Digital Output (Minimum 5 each), Fault Record (Minimum 10) and Event Record (Minimum 100), for the following.	Breaker ON, OFF, Trip	Voltmeter and VSS
2.1	IDMT and Instantaneous 3 O/C + 1 E/F (50, 51, 50N, 51N)	DC Supply ON, AC Supply ON	MFM with Communication Port Equivalent to Schneider (Conzerv) EM 6400NG with RS 485 (Cl. 0.5s)
2.2	Under Voltage and Over Voltage with Time Delay (27/59)	Spring Charge	
2.3	Trip Circuit Supervision (95)	Test and Service Position	
2.4	Circuit Breaker Protection/Failure (50 BF)	Trip Circuit Healthy	
2.5	Anti-Pumping Relay	Minimum 12 Window Annunciation Panel	

3	Master Trip Relay (High Speed Trip Relay) with Hand Reset Contact (2 NO and 2 NC contact)		

Outgoing (Transformer) HV breaker shall be with following as a minimum.

Sr. No.	Relay	Indication and Monitoring	Digital Type Meter
1	Numerical Relay with RS 485 Communication with Combined Protection with Configurable Digital Input and Digital Output (Minimum 5 each), Fault Record (Minimum 10) and Event Record (Minimum 100), for the following.	Breaker ON, OFF, Trip	PF Meter & Ammeter and ASS
1.1	IDMT and Instantaneous 3 O/C + 1 E/F (50, 51, 50N, 51N), Thermal Overload (49)	DC Supply ON	MFM with Communication Port Equivalent to Schneider (Conzerv) EM 6400NG with RS 485 (Cl. 0.5s)
1.2	Trip Circuit Supervision (95)	Spring Charge	
1.3	Circuit Breaker Protection/Failure (50BF)	Test and Service Position	
1.4	Anti-Pumping	Trip Circuit Healthy	
2	Auxiliary Relay for WTI, OTI, Bucholz Alarm Indication and Trip	12 Window Annunciation Panel or Higher as Required.	
3	Master Trip Relay (High Speed Trip Relay) with Hand Reset Contact (2 NO and 2 NC Contact)		
4	Restricted Earth Fault (REF) and Differential Earth Fault Protection Relay for Transformer Rating 2000 kVA and Above		

CBCT shall be provided for Sensitive Earth Fault (SEF) for transformer feeder.

Outgoing (Motor Feeder) HV Breaker shall be with following as a minimum.

Sr. No.	Relay	Indication and Monitoring	Meter
1	Numerical Relay with RS 485 communication with Combined Protection with Configurable Digital Input and Digital Output (Minimum 5 each), Fault Record (Minimum 10) and Event Record (Minimum 100), for the following.	Breaker ON, OFF, Trip	PF Meter & Ammeter and ASS
1.1	IDMT and Instantaneous 3 O/C + 1 E/F (50, 51, 50N, 51N), Thermal Overload (49), Negative Phase Sequence Overcurrent (46), Locked Rotor during Start-up (51S), Under Current/Loss of	DC Supply ON,	MFM with Communication Port Equivalent to Schneider (Conzerv)

	Load (37), Start/Stalled Protection/Motor Re-Acceleration (48/51 LR), Number of Starts Limitation (66), RTD Temperature Monitoring (38/49T)		EM 6400NG with RS 485 (Cl. 0.5s)
1.2	Trip Circuit Supervision (95)	Spring Charge	
1.3	Circuit Breaker Protection/Failure (50BF)	Test and Service Position,	
1.4	Anti-Pumping Relay	Trip Circuit Healthy	
2	Master Trip Relay (High Speed Trip Relay) with Hand Reset Contact (2 NO and 2 NC Contact)	Minimum 12 Window Annunciation Panel or Higher as Required.	

CBCT shall be provided for SEF for outgoing feeder for cable protection.
Numerical protection relay for motor feeder shall be MiCOM 220 with RS 485 of Schneider or Equivalent of any approved make.

Relays and Meters

MFM shall be microprocessor based numerical and communicable type with RS 485 port. Communication link shall be provided between MFM and numerical relays for further communication to PLC/SCADA.
All instantaneous current protection relays shall be of 3 pole type.
Relays shall be rated for operation on 110V DC secondary voltage and 1A secondary current. Number and rating of relay contacts shall suit the job requirements.
All relays shall furnish, install and coordinate to suit the protection and interlock requirement of VCB panel.
Relay shall be low burden, provided with RS 485 computer communication port for monitoring and operation from Remote location/PLC with suitable Software.

Current Transformer

Current transformers shall be cast resin type and shall be as per IS: 2705 (Part 1 to 4).
CTs shall have shorting link on secondary side to facilitate insertion of meters on secondary side without opening CT circuits.
Accuracy class of the current transformers shall be as under.

a) Class PS for differential and restricted earth fault relaying.
b) Class 5P10 for other relaying.
c) Class 0.5 for MFM.
d) ISF < 5 for metering.

The CTs shall be capable for safely withstanding the short circuit stresses corresponding to the fault level as indicated and shall be able to meet short-time requirement specified.
All CT secondary shall be earthed through separate switch link on terminal block.
CT terminals and their polarities shall be clearly marked.

Voltage Transformer

Voltage transformer shall be provided in separate cubicle.
PTs, connection, insulation levels shall be similar to rating of associated breaker.
VA burden shall be selected based on requirement for meters, closing, tripping and indicating circuit.
Voltage transformer shall be cast-resin, draw-out type, dual core (for secondary) for metering and protection separately and shall have an accuracy class 0.5 and 3P for metering and protection respectively.
Voltage transformer mounted on breaker carriage is not acceptable.
The PTs shall be of shell type single phase construction with HRC fuses at both ends and plug-in connection on primary side.
High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw-out position.

Control MCB of suitable rating shall be provided on the secondary side to prevent overload. The PTs shall be capable of operating continuously at 110% of the rated voltage without any damage. When star-star connection is required in non-effective or under grounded system, the PTs shall be suitable for continuous operation with a persistent phase to ground fault.

Indication and Monitoring Instruments

Control cabinet, mounted on top of breaker cabinet, provided with suitable anti-vibration facilities and one number heavy duty spring return type TRIP-NORMAL-CLOSE control switch with pistol grip lockable handle.
Indicating lights to be provided in front of compartments as a minimum.

Green	:	Breaker Open
Red	:	Breaker Closed
Amber	:	Auto Trip
White	:	Trip Circuit Healthy
Yellow	:	Breaker Test Position
Blue	:	Breaker Service Position
DC supply ON	:	White

Indicating lamps shall be 20 mm dia LED type with series resistance. Lamp and lens shall be replaceable from the front.
All indicating instruments shall conform to IS: 1248 (1983) and IS: 2419 (1979) and shall be capable of withstanding system fault current taking into account CT saturation, back connected and located in the upper part of the panel.

Meters

Indicating instruments shall be minimum 96 sq.mm. dial flush mounted digital type with accuracy class 0.5 minimum.
Digital type Multi Function Meter shall be three line display of accuracy class 0.5s for incomer and outgoing and suitable for measuring and digitally displaying following parameters. kVA, kW, kWh, kVA, kVAh, kVAr, kVArh, A, V, PF, frequency, Harmonic, MD measurement and control (MD control only in incomer feeder). Minimum 2 nos. digital output shall be available.
Each meter will be provided with at least two output signals of 4-20 mA and communication port (RS 485) for all above parameters for monitoring and operation from Remote location/PLC with suitable Software.
Meter selector switches shall maintain firm contact, stay put type with knob handle. Ammeter selector switches shall be four-position type having make before break contacts to prevent open circuit of CT secondary. Digital Power factor meter shall be provided separately for Incoming and Outgoing Feeder.

Annunciation

It shall be static type suitable to work on AC supply as specified.
Hooter and bell for trip and alarm indication respectively.
Test, accept and reset facilities (with push button) shall be provided on each panel.
Suitable audio-visual indication shall be provided on DC failure. Audio alarm with reset facility shall be provided. Visual indication shall be given panel wise.
Spare annunciation points shall be wired up to terminal blocks. 20% spare facia shall be provided.
Sequence shall be as follows.

	VISUAL	**AUDIO**
On Occurring of Fault	Flashing	On
On Accepting	Steady On	Off
On Reset (Fault Cleared)	Off	Off
On Reset (Fault Persists)	Steady On	Off

Warning and emergency points shall be as per the list approved during detailed engineering stage.
One common point shall be provided to indicate operation of annunciation system of the complete panel (in case of any trouble in the panel in tie feeder, bus coupler, incomer etc.). Remote and annunciation facia window details shall be finalized during detailed engineering.
A common audible alarm for each switchgear line up shall be provided to alert the Operator that circuit breaker has tripped. Means shall be provided for silencing the audible alarm whilst leaving it free to sound when any other alarm is initiated but the associated alarm indications shall continue until cancelled.

Secondary Wiring

Switchgear panel shall be fully wired at the factory to ensure proper functioning of control, protection, transfer and interlocking schemes.
Control MCB of suitable rating shall be provided to permit individual circuit isolation from bus/ wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
Wiring shall be done with flexible, 650V grade; FRLS PVC insulated wires with stranded Copper conductors of 1.5 mm^2 for control current circuits and voltage circuits. All power wiring like space heater supply etc. shall be carried out with min. 2.5 mm^2 PVC insulated Copper conductor wire.
Each wire shall be identified at both ends with dependent and cross addressing permanent markers bearing wire numbers. Trip circuit shall have red colour ferrule.
Wire termination shall be made with crimping type ring connectors with insulating sleeves. Wires shall not be spliced between terminals.
The wires shall run preferably through PVC channel with cover adequately supported along its run to prevent sagging due to flexibility or vibration. The control and power wires shall be routed through separate channels.
Inter panel wiring PVC channel shall be furnished for wiring between switchgear cubicles. All wiring required for interlocking between the cubicles of any switchgear shall be furnished and installed. Wherever wires are passing through cutouts or openings, they shall be protected by providing suitable grommet or gasket around the openings. Inter panel wiring at shipping sections shall be through terminal blocks placed suitably at intersection points.
The colour of wire shall be taken as follows.

AC System	:	Black
DC System	:	Grey
Earthing System	:	Green
CT and PT Wiring System	:	Red, Yellow, Blue Color Code

Terminal Blocks

Terminal blocks shall be 660V grade box clamp type with 10 mm^2 marking strips.
Terminal for PT secondary lead shall be disconnecting link type. Power wiring circuits and PT secondary wiring circuits shall be terminated by bolt type terminal blocks and rest by screw type terminal blocks.
Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished. Multi connection terminal strip to be used if required.
Wiring shall be so arranged that an external cable can be connected to consecutive terminals.
Terminal blocks for external/space heater wiring shall be separate from inter panel wiring.
All control wire shall be terminated with ring type insulated lug only.
The terminal block shall be grouped according to circuit functions and individual terminals in each block shall be serially numbered in accordance with the drawings. Such numbering shall be legible, permanent and indelible.
Communication port of meters and relays of individual breaker panel shall be looped together and brought out at External Terminal Connector/Block using instrument signal cable 1 pair, annealed Tinned Copper conductor flexible cable.
All spare contacts of Breaker, CT, Relay, Annunciator etc. shall be wired upto external TB.

Cable Termination

Switchgear panel shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection with suitable size gland plates with knock out plates for specified HV cable connection.
The design of cable box shall be such that any type of jointing methods such as heat shrinkable/push on type/cold shrinkable type termination can be adopted.

Ground Bus

A ground bus shall be minimum 40mm x 6mm Tinned Copper or higher as per requirement, shall extend the full length of the switchgear panel in all compartments includeing cable compartments etc.
Each stationary unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw-out PT unit shall be grounded through heavy multiple contacts.
CT and PT secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing other.
All hinged doors shall be grounded using silver plated and braided copper flexible of adequate size.

Name Plates

Name plate shall be provided as per standard.

Space Heaters and Plug Sockets

Each cubicle shall be provided with thermostat controlled space heaters and 5/15A, 6 pin plug socket, panel illumination lamp. Cubicle heater, plug/socket circuits shall have individual MCBs.
230V AC supply for HV panel shall be taken from LV panel in the plant/pumping station.

Auxiliary Power and Control Supply

a) Control voltage shall be for
   - Closing, Tripping Coil : 110V DC
   - Indication Circuit : 110V AC
   - Spring charging motor, panel space heater, 3 pin socket and panel illumination : 230V AC

b) Bus wires of adequate (minimum 4 sq. mm. Copper) capacity shall be provided to distribute the incoming supplies to different cubicles.
c) DP MCB shall be provided at switchgear for the incoming supplies 230V AC supply and 110V DC supply (as applicable).
d) Battery backup/power pack unit (1 No.) shall be provided for switchgear panel for 110V AC/110V DC for closing and trip circuit suitable for minimum two successive open and close operations after failure of power. Power pack connected on 110V AC PT supply OR 110V DC, shall be minimum 100 Ah capacity or higher as required.
e) Battery and Battery Charger and DCDB shall be provided if specified in the scope of work/SOQ.

Tropical Protection

- All equipment, accessories and wiring shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
- Screens of stainless steel shall be furnished on all ventilating louvers to prevent entrance of insects.

Painting

The HV panel shall be treated with seven tank process with cleaning of scale, grease, rust and foreign adhering matters and chemical de-rusting, sand blasting, degreasing, pickling in acid bath and phosphating as per IS: 6005 and primed.
After cleaning, the surfaces shall be given 2 coats of epoxy primer.
After seven tank process and primer coating, panel shall be powder coated with **RAL 7035** for inside and outside of the entire panel.

Inspection and Tests

The switchgear panel shall be completely assembled, wired, adjusted, inspected and tested at the factory/works as per relevant applicable standards.

Routine Tests

The tests shall include but not necessarily limited to the following for switchgear panel.

a) Operation under simulated service condition to ensure accuracy of wiring, correctness of control scheme and proper functioning of the equipment.
b) All wiring and current carrying part shall be given appropriate High Voltage test.
c) Primary current and voltage shall be applied to all instrument transformers.
d) Routine test shall be carried out on all equipment such as circuit breakers, instrument transformers, meters etc.
e) Power frequency withstand insulation HV test for main circuits, auxiliary and control circuit as per relevant IS.
f) Milli-volt drop test across main contacts of each phase of VCB and close and open time test for VCB shall also be a part of Routine Test.

Test Witness

Panel builder/integrator/manufacturer shall perform all the tests as per IS/IEC Standards and specifications on all the panels (100% quantity of the project/tender lot) @ factory/works' in presence of Client/PMC/TPI.

Test Certificate

a) Certified reports of all tests carried out at factory/works shall be furnished in four (4) copies for approval of the Client.
b) The panel shall be dispatched from factory/works only after receipt of Client's written approval.
c) The test reports shall furnish complete identification of panel such as serial number, rating, equipment designation as per drawings/documents etc. and date of tests carried out.

❖ 11 KV OUTDOOR RING MAIN UNIT

General

All equipment and material shall be designed manufactured and tested in accordance with the latest applicable IEC standards or any other standards ensuring equal or better quality.

The electrical installation shall meet the requirement of Indian Electricity Rules 1956 as amended up to date; relevant IS code of practice and Indian Electricity Act 1910 including all other applicable rules and regulations.

Scope

Design, engineer, manufacture, assembly, factory inspection and testing before supply at site, installation, testing & commissioning of RMU outdoor type SF6 filled, with various combinations of load break isolators and breakers including plate type earthing with 35mm GI earthing strip. The scope includes erection, testing and commissioning of complete RMU with associated equipment including civil work,

supply & laying of 11kV cable, cable jointing kit, fencing etc. along with obtaining required permission of charging from the Electrical Inspector.

The insulation/dielectric media inside the stainless-steel welded tank should be SF6 gas. The RMU should be modular, extensible type on both sides with provision of attaching/ connecting with SNAP FIT arrangement without external bus bars additional load break switches and circuit breakers in future whenever required. However left side of RMU shall have metering panel on the left side and right side shall be free for extension on vice versa depending on site condition. Alternatively, extension shall be possible by adding trunking chambers and required accessories or by plug-in bushing type arrangement.

Ring main unit shall be capable of being monitored and controlled by the SCADA if & as required.
Each RMU shall be equipped with main-line load break switches and a fault passage indicator (FPI). Furthermore, to protect each of its lateral/transformer feeders, it shall be equipped with a corresponding set of circuit breakers and relay with provision of auxiliary supply.

Required configuration shall be as per SOQ/Site Requirement. Broadly it shall be as follows.

a) 1 Way: 11kV Gas (SF6) insulated RMU with one 630A load break switch and one SF6 insulated VCB of suitable rating as per SOQ/site requirement.

b) 2 Way: 11kV Gas (SF6) insulated RMU with two 630A load break switch and two SF6 insulated VCB of suitable rating as per SOQ/site requirement.

The normal current rating of VCB shall be according to the load of the feeder along with suitable Relay. Any change in combination/configuration shall be executed with the prior approval of the Client/Consultant.

Technical Requirements

- Fixed type SF 6 gas insulated/vacuum circuit breakers.
- The RMU shall be: Compact with minimum space requirement i.e. small construction width; maintenance free; able to operate in severe outdoor environmental conditions and climate; immune to electrical stress and disturbance; acceptable insulation properties; easy installation; safe, easy & reliable operation.
- The type of the 11kV circuit breakers shall be VCB and insulating medium for load break isolators, earth switch, 11kV buses and other associated equipment should be SF6 gas.
- Motorized operation of Load break switch and vacuum circuit breaker.
- Necessary current sensors/transformers for protection and metering (wherever required).
- All necessary dry (potential-free) contacts for indications relevant to RMU monitoring status and control (wherever required).
- Low gas pressure devices: 1.4 bar pressure & 1.4 bar pressure of SF6 gas in chamber of RMU is required.
- Live cable indicators: High Operator safety.
- Fully rated integral earthing switch on each device.
- Back up relay with auxiliary supply shall be provided.
- For indoor cable boxes should be front access and interlocked with earth switch. No rear/side access required. For outdoor RMU cable boxes shall be on front.
- Cable testing possible without disconnection of cables.
- Compact in dimension.
- Circuit breaker with back up relay with auxiliary supply shall be provided.
- Low pressure, sealed for life equipment, can operate at “0” bar pressure.

- Cable earthing switch on all switching device-standard, for Operator safety.
- Enclosure of outdoor RMU shall conform to the degree of protection IP 5X.

Technical Particulars

Vendor/Contractor shall furnish all guaranteed technical particulars as described in this specifications & data sheet.

The entire RMU shall be enclosed in a single compact metal clad, outdoor enclosure suitable for all weather conditions. The switchgear/steel gas tank shall be filled with SF6 as per IEC/IS standards relative pressure to ensure the insulation and breaking functions. The steel gas tank must be sealed for life and shall meet the "sealed pressure system" criteria in accordance with the IEC 298 standard. The RMU must be a system for which no handling of gas is required throughout its service life.

The RMU shall have a design such that in the event of an internal arc fault, the Operator shall be safe. This should be in accordance with IEC 298 and relevant test certificates shall be submitted @ time of inspection.

The offered switchgear and control gear should be suitable for continuous operation under the basic service conditions indicated below. Installation should be in normal indoor conditions in accordance with IEC 60694.

RMU shall be tested for an internal arc rating of 26kA for 1 second for 11kV RMU. Suitable temperature rise test on the RMU shall be carried out and test reports shall be submitted @ time of inspection.

It shall be identified by an appropriately sized rating plate/label clearly indicating the functional units and their electrical characteristics.

The switchgear and switchboard shall be designed so that the position of the different devices and their operations are visible to the Operator on the front of the switchboard.

The entire system shall be totally encapsulated. There shall be no access to the exposed conductors in accordance with the standards. In effect, the switchboard shall be designed so as to prevent access to all live parts during operation without the use of tools.

The entire RMU is insulated by inert gas (SF6) and shall be suitable for operating voltage up to 12 kV. Suitable absorption material shall be provided in the tank to absorb moisture from SF6 gas. The SF6 insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering an indication at different temperature ranges, having distinctive RED and GREEN zones for safe operation.

RMU must be routine tested for the following at factory.

- Micro-ohm test (Contact Resistance Test) for the assembly inside the tank.
- Circuit breaker analyser test so as to ensure the simultaneous closing of all poles for VCB.
- SF6 gas leak test.
- Partial discharge test on the complete gas tank so as to be assure of the proper insulation level and high product life.
- High voltages withstand.
- Secondary test to ensure the proper functioning of the live line indicators, fault passage indicators and relays.

- As per IEC/IS standards mechanical operation of RMU switch must be carried out.

Sulphur Hex fluoride Gas (SF6 GAS)

The SF6 gas shall comply with IEC 376, 376-A and 376-B and shall be suitable in all respects for use in 11kV RMU under the operating conditions. The SF6 shall be tested for purity, dew point air hydrolysable fluorides and water content as per IEC 376, 376-A and 376-B and test certificate shall be furnished to the Client/Consultant indicating all the tests as per IEC 376 for each lot of SF6 Gas.

Dielectric Medium

SF6 gas/VCB shall be used for the dielectric medium for 11kV RMU in accordance with IEC 376. Suitable absorption material shall be provided in the tank to absorb the moisture from the SF6 gas/VCB and to regenerate the SF6 gas/VCB following arc interruption. The SF6 gas/ VCB insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering a simple go & no-go indication.

Structural and Mechanical Construction

The offered RMU should be of the fully arc proof metal enclosed, free standing, floor mounting, flush fronted type, consisting of modules assembled into one or more units. Each unit is to be made of a cubicle sealed-for life with SF6 gas/VCB and shall contain all high voltage components sealed off from the environment.

The overall design of the switchgear should be such that only front access is required. It should be possible to erect the switchboard against a substation wall, with HV and LV cables being terminated and accessible from the front.

The unit should be constructed from minimum 2mm thick stainless-steel sheets. The design of the unit shall be such that it facilitates the unit being lifted by eyebolts or moved into position by rollers without any permanent damage or harm.

For outdoor RMU, a weather proofing process shall be carried out. Sheet metal must be grit blazed/thermally sprayed and polyurethane painted with about 80 micron thickness to achieve outdoor worthiness and corrosion proof ness.

RMU enclosure must be shielded against solar irradiation and tested for ambient of 50^0 C without de-rating of the equipment.

The cubicle shall have a pressure relief device. In the rare case of an internal arc, the high pressure caused by the arc will release it, and the hot gases is allowed to be exhausted out at the bottom/top/rear of the cubicle. A controlled direction of flow of the hot gas should be achieved.

The switchgear should have the minimum degree of protection (in accordance with IEC 60529).

- IP 67 for the tank with high voltage components
- IP 2X for the front covers of the mechanism
- IP 3X for the cable connection covers
- IP 54 for the outdoor enclosure

Metal Clad Enclosure

RMU shall be stainless steel enclosed type & tropicalized suitable for outdoor installation. RMU metal parts shall be of high thickness, high tensile steel which must be grit/short blasted, thermally sprayed with Zinc alloy, phosphate or should follow the 7 tank pre-treatment process and be subsequently painted with Polyurethane/PP based powder paint. The overall paint layer thickness shall be not less than 80 microns.

Relevant IE rules for clearances, safety and operation inside the enclosure shall be applicable. The enclosure shall be IP 54 and type tested for weather proof at ERDA/CPRI.

The equipment should also be designed to prevent ingress of vermin, accidental contact with live parts and to minimize the ingress of dust and dirt. The use of materials which may be liable to attack by termites and other insects should be avoided.

All live parts except for the cable connections in the cable compartments shall be insulated with SF6 gas. The SF6 gas tank shall be made of robotic or TIG or MIG welded stainless steel of thickness as per IEC tested/designed with the best weld quality so as to provide safety and to avoid leakage of gas. It should be provided with a pressure relief arrangement away from the Operator.

The cable termination chamber of isolators and circuit breakers both should be of front access type/round end type as per site requirement.

Any accidental over pressure inside the sealed chamber shall be limited by the opening of a pressure-limiting device in the top or rear-bottom part of the tank or enclosure. Gas will be released to the rear of the switchboard away from the Operator and should be directed towards the bottom, into the trench to ensure safety of the Operating personnel. All the manual operations should be carried out on the front of the switchboard.

The rating of enclosure shall be suitable for operation on three phase, three wire, 11kV, 50 cycles AC system with short-time current rating of 26kA for 1 seconds for 11kV with RMU panels.

The enclosure should have two access doors one for the operation and relay monitoring and other for the cable access. Both the doors should have the locking facility to prevent the access to operating mechanism to avoid unauthorized operating of RMU and relay.

Isolators (Load Break Type)

The load break isolators for incoming and outgoing supply must be provided & be fully insulated by SF6 gas. The load break isolators shall consist of 630A fault making/load breaking spring assisted ring switches, each with integral fault making earth switches. The switch shall be naturally interlocked to prevent the main and earth switch being switched "ON" at the same time. The selection of the main and earth switch is to be made by a lever on the facia, which is allowed to move only if the main or earth switch is in the "OFF" position. The load break isolators should have the facility for remote operation. Each load break switch shall be of the triple pole, simultaneously operated, automatic type with quick break contacts and with integral earthing arrangement.

The isolating distance between the OFF and ON position in the isolator should be sufficient to withstand dielectric test as per IS/IEC so as to have enough isolating distance for ensuring safety during D C injection for cable testing.

Load break switch should have the following.

- Motor operated 12kV, 630A load break switch and manually operated earthing switch with making capacity
- "Live cable" LED indicators through capacitor voltage dividers mounted on the bushings
- Mechanical ON/OFF/EARTH indication and interlocking between earth and on/off conditions

- Anti-reflex operating handle
- Cable testing facility without disconnecting the cable terminations, cable joints and terminal protectors on the bushings.

Cable terminations

Cable boxes suitable for minimum 1 x 3C x 300 sq. mm. XLPE cable with right angle cable termination protectors.

Earthing of Isolators and Breakers (Earth Switch): Necessary arrangement shall be provided at load break isolators breaker for selecting earth position. Mechanical interlocking system shall prevent RMU function from being operated from the "ON" to "Earth On" position without going through the "OFF" position.

Distribution Transformer (DT)/Feeder Breaker (Vacuum)

The VCB breaker for the controlling of DT/feeder breaker must be provided inside welded stainless steel SF 6 gas tank with the outdoor metal clad enclosure. The VCB circuit breaker must be spring assisted three positions with integral fault making earth switch. The selection of the main/earth switch lever on the facia, which is allowed to move only if the main or earth switches is in the off position.

The manual operation of the circuit breaker shall not have an effect on the trip spring. This should only be discharged under a fault (electrical) trip; the following manual reset operation should recharge the trip spring and reset the circuit breaker mechanism in the main off position.

The circuit breaker shall be fitted with a mechanical flag, which shall operate in the event of a fault (electrical) trip occurring. The "tripped" flag should be an unambiguous colour differing from any other flag or mimic.

Both the circuit breaker and ring switches are operated by the same unidirectional handle. The protection on the circuit breaker shall comprise of the following components.

- 5P10 class protection CTs,
- Low burden trip coil and
- O/C & E/F relay with auxiliary supply (24V DC) shall be provided IDMT protection relays (Microprocessor based) 3 x over current and earth fault element shall be Definite time type relay. The relay should be housed within a pilot cable box accessible.

The nominal current rating of protection class CT shall be as specified in SOQ or actual requirement and accordingly suitable numerical relay shall have to be provided.

The minimum relay current setting range for O/C: 20% to 250% and E/F: 10 to 250% should be from 2% to 100%.

Any change in combination/configuration shall be executed with the prior approval of the Client/Consultant.

Vacuum Circuit Breaker should have the following.

- Motor operated 630A SF6 insulated vacuum circuit breaker and earthing switch with making capacity 50kA
- Mechanical tripped on fault indicator
- Auxiliary contacts 4 NO and 4 NC
- Anti-reflex operating handle
- "Live Cable" LED Indicators through capacitor voltage dividers mounted on the bushings
- O/C + E/F relay with auxiliary supply (24V DC) shall be provided.
- Shunt trip circuit for external trip signal
- Mechanical ON/OFF/EARTH indication

- Cable boxes suitable for minimum 1 x 3C x 300 sq. mm XLPE cable with right angle cable termination/protectors/boots.

Bushings

The units are to be fitted with the standardized bushings that comply with IEC standards. All the bushings are the same height from the ground and are protected by a cable cover.

Cable Boxes

All the cable boxes shall be air insulated suitable for dry type cable terminations and should have front access. The cable boxes at each of the two ring switches should be suitable for accepting HV cable of minimum 3C x 300 sq. mm. size and circuit breaker cable suitable up to minimum 3C x 300 sq. mm. size. The cable boxes for an isolator in its standard design should have sufficient space for connecting two cables per phase.

Necessary right angle boot should be supplied to the cable terminations. The type of the right -angle boot should be cold applied insulating boot. In cable box bushing fitting required shall be 3 KN capacity.

Cable Testing Facility

It shall be possible to test the cable after opening the cable boxes. The cable boxes should open only after operation of the earth switch. Thus, ensuring the earthing of the cables prior to performing the cable testing with DC injection.

Voltage Indicator Lamps & Phase Comparators

RMU shall be equipped with a phase wise voltage indication to indicate whether or not there is voltage on each phase of cable. There should be a facility to check the synchronization of phases with the use of external device. It shall be possible for the each of the function of the RMU to be equipped with a permanent voltage indication as per IEC 601958 to indicate whether or not there is voltage on each phase cables. Indicator should be visible from outside without opening door.

Extensible Type

Each combination of RMU shall have the provision for extension both sides by load break isolators/breakers in future, with suitable accessories and necessary bus bar. The equipment shall be well designed to provide any kind of extension/trunking chamber for connecting and housing extensible bus bars. Extensible isolators and circuit breakers shall be individually housed in separate SF6 gas enclosures. Multiple devices inside single gas tank/enclosure will not be acceptable. In case of extensible circuit breakers, the breaker should be capable of necessary short circuit operations as per IEC at 26kA, and the breaker should have a rated current carrying capacity of 630A.

Wiring and Terminals

The wiring should be of high standard and should be able to withstand the tropical weather conditions. All the wiring and terminals (including take off terminals for future automation, DC, Control wiring), 20% Spare terminals shall be provided by the Vendor/Contractor. The wiring cable must be standard single-core non-sheathed, core marking (ferrules), stripped with non-notching tools and fitted with end sleeves, marked in accordance with the circuit diagram with printed adhesive marking strips.

The wiring shall be carried out using multi-strand copper conductor super flexible PVC insulated FRLS wires of 1100V grade for AC power, DC control and CT circuits. Suitable coloured wires shall be used for phase identification and interlocking type ferrules shall be provided at both ends of the wires for wire identification. Terminal should be suitably protected to eliminate sulphating. Connections and terminal should be able to withstand vibrations. The terminal blocks should be stud type for controls and disconnecting link type terminals for CT leads with suitable spring washer and lock nuts.

Flexible wires shall be used for wiring of devices on moving parts such as swinging panels (switch gear) or panel doors. Panel wiring shall be securely supported, neatly arranged readily accessible and connected to equipment terminals, terminal blocks and wiring gutters. The cables shall be uniformly bunched and tied by means of PVC belts and carried in a PVC carrying trough.

The position of PVC carrying trough and wires should not give any hindrance for fixing or removing relay casing, switches etc. Wire termination shall be made with solder-less crimping type of tinned copper lugs. Core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted with both ends of each wire. Ferrules shall fit tightly on the wire when disconnected. The wire number shown on the wiring shall be in accordance with the IS: 375.

All wires directly connected to trip circuits of breaker or devices shall be distinguished by addition of a red colour unlettered ferrule.

Inter-connections to adjacent panels (switch gear) shall be brought out to a separate set of terminal blocks located near the slots or holes to be provided at the top portion of the panel. Arrangements shall be made for easy connections to adjacent panels (switch gear) at site and wires for this purpose shall be provided and bunched inside the panel. The bus wire shall run at the top of the panel.

Terminal block with isolating links should be provided for bus wire. At least 20% of total terminals shall be provided as spare for further connections. Wiring shall be done for all the contacts available in the relay and other equipment and brought out to the terminal blocks for spare contacts. Colour code for wiring is preferable in the following colours.

- Voltage Circuits : Red, Yellow, Blue for phase and Black for Neutral
- CT Circuits : Similar to the above
- DC circuits : Grey for both positive and negative
- 250V AC circuits : Black for both phase and neutral
- Earthing : Green

The wiring shall be in accordance to the wiring diagram for proper functioning of the connected equipment. Terminal blocks shall not be less than 1100V grade and shall be piece-moulded type with insulation barriers.

The terminal shall hold the wires in the tight position by bolts and nuts with lock washers. The terminal blocks shall be arranged in vertical formation at an inclined angle with sufficient space between terminal blocks for easy wiring.

The terminals are to be marked with the terminal number in accordance with the circuit diagram and terminal diagram. The terminals should not have any function designation and are of the tension spring and plug-in type.

Earthing

RMU outdoor metal clad, switch gear, load break isolators, vacuum circuit breakers shall be equipped with an earth bus securely fixed along the base of the RMU.

The size of the earth bus shall be made of IEC/IS standards with tinned copper flat for RMU and MS flat for distribution transformer, earth spike and neutral earthing. Necessary terminal clamps and connectors shall be included in the scope of supply.

All metal parts of the switchgear which do not belong to main circuit and which can collect electric charges causing dangerous effect shall be connected to the earthing conductor made of Copper having cross section area of minimum 75 sq. mm. Each end of conductor shall be terminated by M 10/ equivalent quality and type of terminal for connection to earth system installation. Earth conductor location shall not obstruct access to cable terminations.

The following items are to be connected to the main earth conductor by rigid or copper conductors having a minimum cross section of 75mm (a) earthing switches, (b) cable sheath or screen (c) capacitors used in voltage control devices, if any.

The metallic cases of the relays, instruments and other panel mounted equipment shall be connected to the earth bus by independent copper wires of size shall be made of IEC/IS standards. The colour code of earthing wire shall be green. Earthing wires shall be connected on the terminals with suitable clamp connectors and soldering shall not be permitted.

Two nos. of earthing with connecting Copper/Aluminium/GI strips of required size are to be provided as per IS: 3043.

Fault Passage Indicators (FPI)

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU. The FPI shall have LCD/LED display, automatic reset facility.

The sensors to be bushing/cable mounted. The number of FPI should be put in all the three phases of the outgoing branch of the RMUs.

FPI should have suitable connectivity with the FRTUs for the SCADA purpose if and as required. FPI has to give indication on short circuit and earth fault both.
FPI Indication should be visible from outside without opening of door.

The FPI inside the RMU may be non-communicable and hard wired to the TB for the signals.

Fault Passage indicator OK
Fault Passage indicator operated

The conventional practice is to have (N-1) FPI where N is nos. of LBS in a particular configuration of RMU.

Accessories and Spares

The following spares and accessories shall be supplied along with the main equipment. These shall deemed to be included in the unit of RMU.

1. Charging lever for operating load break isolators & circuit breaker of RMU.
2. The pressure gauge indication: 1 number

Provision shall be made for padlocking the load break switches/circuit breaker, and the earthing switches in either open or closed position with lock & master key.

Name Plate

RMU and its associated equipment shall be provided with a name plate legible and indelibly marked with at least the following information.

a. Name of manufacturer
b. Type, design and serial number
c. Rated voltage and current
d. Rated frequency
e. Rated symmetrical breaking capacity
f. Rated making capacity
g. Rated short time current and its duration
h. Month and Year of supply
i. Rated lightening impulse withstand voltage
j. Feeder name (Incoming and Outgoing), DTs Structure name, 11000 Volts Dangers etc.
k. Name of Client

Tests

Acceptance and Routine Tests

All acceptance and routine tests as stipulated in the latest IEC shall be carried out by the Vendor in the presence of Client/Consultant. The partial discharge shall be carried out as routine test on each completely assembled RMU gas tank and not on a sample basis. As this test checks and guarantees for the high insulation level and thus the complete life of switch gear.

Type Test

The vendor shall submit copy of type test certificate as confirming to relevant ISS/IEC of latest issue obtained from International/National Government Laboratory/Recognized Laboratory @ the time of inspection for review & acceptance by the Client/Consultant.

Pre Commissioning Tests @ Site

All the pre-commissioning tests will be carried out in the presence of the Engineer-in-charge of the Client and necessary drawing manual and periodical test tools shall be arranged to enable conducting such tests.

During the above tests the Vendor/Contractor's engineer should be present @ site till the RMU is put in to service.

Inspection

The inspection may be carried out by the Client at final stage of manufacture i e pre dispatch. Inspection and acceptance of any equipment under this specification by the Client shall not relieve the supplier of his obligation of furnishing equipment in accordance with the specification and shall not prevent subsequent rejection if the equipment is found to be defective.

The supplier shall keep the Client informed in advance, about the manufacturing programme so that arrangement can be made for inspection. The Client reserves the right to insist for witnessing the acceptance/routine testing of the bought out items. The Client has rights to inspect the supplier's premises for each and every consignment for type & routine test.

No material shall be dispatched from its point of manufacture unless the material has been satisfactorily inspected and tested/unless the same is waived by the Client in writing.

Documentation and Drawings

All drawings shall conform to relevant International Standards Organization (ISO)/IEC standards/ specifications.

The Vendor/contractor shall submit following drawings & documents of the equipment, illustrative and descriptive literature in quadruplicate for various items in the RMU.

I. General Arrangement Drawings & Schematic Diagram
II. Instruction & Operation/Maintenance Manuals

III. Catalogues & List of Spares recommended
IV. Drawings of equipment, relays, control wiring circuit, etc.
V. Foundation drawings of RMU and relevant civil works etc.
VI. Single line diagram of RMU.
VII. Data sheet as specified in relevant section.
VIII.

Quality Assurance Plan

The Vendor/Contractor shall invariably furnish following information.

I. Statement giving list of important raw materials including but not limited to
a) Contact material
b) Insulation
c) Sealing material
d) Contactor, limit switches etc. in control cabinet.

Name of sub-suppliers for the raw materials, list of standards according to which the raw materials are tested, list of tests normally carried out on raw materials & copies of test certificates.

II. Information and copies of test certificates as in (I) above in respect of bought out accessories & raw materials.
III. Quality control tests and inspections.
IV. Special features provided in the equipment to make it maintenance free.
V. Quality Assurance Plan (QAP) points for Client/Consultant's inspection.

❖ DISTRIBUTION TRANSFORMERS

Scope

The scope covers the detailed requirements regarding supply, installation, testing, commissioning of transformers required for the indoor/outdoor installation in substation, meeting the requirements specified in the data sheet.

Associated civil works i.e. RCC pedestal/platform and fire wall as required for installation of transformers are also included in the scope.

Standards and Compliances

The transformer shall comply with IS: 2026 (Part I to V) and IS: 1180 Part I (2021) (latest editions) and shall be suitable for service under voltage and frequency fluctuation conditions as permisible under Indian Electricity Act. Transformers shall meet the requirements of governing standards and loading requirements in accordance with IS: 6600.

General Construction

Transformers shall be capable of operating continuously and without adverse effects of overheating under all specified conditions of operation including variation in system of ± 10% voltage and ± 3% frequency or ± 10% combined voltage and frequency unless otherwise specified.

Transformer shall be indoor or outdoor type as specified. Unless otherwise specified the transformer in addition shall have thermal and dynamic ability to withstand external short circuit as per clause 9 of IS: 2026 Part I (1977).

Transformer shall be designed for frequent direct on line starting of motors having an equivalent rating in kVA up to CMR of the transformer and shall be capable of withstanding the forces arising from the starting currents of these motors.

Transformer shall be supplied with first filling of oil and 10% extra oil in non returnable drums conforming to IS: 335. The BDV of oil shall confirm to IS/IEE standards at the time of delivery at site and also at the time of commissioning.

Transformer shall be considered with OLTC and RTCC, if specified otherwise in tender/SOQ.

For transformer rated 2000kVA and above, neutral CTs for stand by Earth Fault and REF protection shall be provided along with differential protection. Neutral CTs shall be provided before bifurcation of neutral.

Creepage distance of 31 kV/mm is to be considered.

All hard ware shall be hot dipped GI.

The Maximum Total Losses and % Impedance for transformer ratings up to and including 2500kVA shall be as per **Energy Efficiency Level 2** as clearly specified in Table 3 (For and Up to 200kVA Ratings) and Table 6 (From 250kVA to 2500kVA Ratings) of IS: 1180 Part I (2021).

For transformer ratings above 2500kVA the maximum permissible losses and % impedance shall be as per CBIP Manual/Publication (Latest Version) and are indicated under as reference.

Transformer Rating	**Maximum Permissible Load Losses with IS Tolerance**	**Maximum Permissible No Load Losses with IS Tolerance**	**% Impedance Voltage with IS Tolerance**
3150kVA	20kW	2.9kW	6.25%
4000kVA	27kW	3.2 kW	7.15%

Taps and Tap Change Gear/Device

Tap changing device to be provided for voltage variation on HV side and shall be either off circuit type or on load type as specified in SOQ/tender.

Off Circuit Tap Change Gear (Off Load Tap Changer)

Off circuit type tape changer shall be externally hand operated with necessary indication for tap position and pad locking arrangement at all tapping positiosn.

It shall be, designed for bi-directional operation; self-positioning type and shall have total seven (7) number of tap positions and voltage variation ranging from +5% to -10% in steps of 2.5%.

The tap changers shall be off circuit type mechanical, rugged and arranged to provide for convenient operation and maintenance without necessity of un-tanking.

The position indicators shall be positive and there shall not be any ambiguity resulting into incomplete tap change with respect to the mechanical tap position indication.

The operating handle of tap changer shall be brought out of the tank at the side at an accessible height from ground level. Tap changer operating switch mounted on the top of the transformer tank will not be acceptable.

Provision of padlocking the tap changers without interfering with visual tap position indicator shall be provided. The tap changing handle shall have locking arrangement of suitable size.

On Load Tap Change Gear (OLTC)

OLTC shall be with +5% to –15% taps in steps of 1.25% on HV winding of transformer. It shall have following technical features.

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 specifications "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. OLTC gear shall withstand through fault currents without injury.

When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.

Oil in compartments which contain making and breaking contacts of OLTC shall not mix with oil in other compartments of the the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by pipe to separate oil conservator or to segregated compartment within the main transformer conservator. An oil surge relay shall be installed in above pipe. The conservator shall be provided with prismatic oil level gauge.

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.

Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection window with view glass.

OLTC driving mechanism and its associated control equipment shall be mounted in outdoor, weather proof cabinet conforming to degree of enclosure i. e. protection IP 55. The finish shall match with that of the transformer on which it is mounted. The cabinet shall include following.

- Driving motor (415V, 3 Phase, 50Hz, AC squirrel cage),
- Mechanically and electrically interlocked motor starting contactors with thermal overload relay, isolating switch and MCCBs,
- 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 number outgoing feeder extending to OLTC driving motor cabinet, with appropriate provision for receiving the same,
- Control switch: Raise/Off/Lower (spring return to normal type) or independent push buttons,
- Emergency **"**OFF**"** push button (maintained type),
- Remote/Local selector switch (maintained contact type),
- Mechanical tap position indicator,
- Limit switches to prevent motor over-travel in either direction or final mechanical stops,
- Appropriate scheme/device to permit only one tap change at a time on manual operation,
- Emergency manual operating device (hand crank or hand wheel),

- A five digit operation counter,
- Space heaters with thermostat and MCB,
- Control transformers with MPCB/MCBs on primary and secondary sides for each supply,
- Interior lighting fixture with lamp, door switch/ON-OFF switch and MCB,
- Gasketted and hinged door with locking arrangement,
- Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables,
- Necessary relays, contactors, current transformers etc. and
- Transducers or any other appropriate device for remote tap position indication.

Control Requirements for OLTC

The following electrical control features shall be provided.

- Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
- Only one tap change from each taps change command even if the command is maintained.
- Cut off of electrical control when manual operation is resorted to.
- Cut off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
- Cut off of electrical control when it tends to operate the tap beyond its extreme position.

Remote Control Equipment

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 IP 42 or better and shall comprise the following.

- Control switches: Raise/Off /Lower (spring return to normal type) or independent push buttons,
- If automatic operation is specified, auto/manual selector switch (maintained contact type) and other items as listed,
- If parallel operation is specified, master/independent/follower selector switch (maintained contact type) with, out of step annunciation,
- Tap position indicator,
- Facia type alarm annunciators with “accept”, “lamp test” facilities and hooter/buzzer for alarms as listed,
- Necessary auxiliary relays,
- Lamp indications for: Tap change in progress, Lower limit reached & Upper limit reached,
- Transformer cooler control apparatus (if applicable),
- Cable glands for power and control cables,
- 240 V rated panel space heater with thermostat,
- CFL type interior lighting fixture with lamp and door switch,
- MCBs,
- Terminal blocks,
- Internal wiring,
- Earthing terminal,
- Hook up for the remote operation of tap lower and raise operation and contact and
- signal for tap position indication to Client’s DCS shall be incorporated in the panel.

Automatic Control of OLTC

Automatic voltage regulator (AVR) for auto control of OLTC shall include following.

- Voltage setting device,
- Voltage sensing and voltage regulating devices,
- Line drop compensator with adjustable R and X elements,
- Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation,
- Adjustable dead band for voltage variation and
- Additional features as required when parallel operation with other transformers is specified.

Alarms

The following alarms shall be provided.

- AC supply failure,
- Drive motor auto tripped,
- Other protective purpose considered essential by the Contractor,
- Out of step operation when paralleled transformers supposed to operate on the same tap are operating at different taps,
- Tap change delayed,
- AVR failure (if AVR is specified),
- For the all specified above a "OLTC trouble" group alarm to be provided in DCS which is located in control room and
- Others, as specified.

Annunciation

Microprocessor based annunciation, minimum 6 window or higher as required shall be provided for following fascia.

- AC supply fail
- out of step relay operated
- tap changer motor trip
- tap change incomplete
- spare
- spare

Tests

1) Routine Tests

Routine tests as per IS: 8468 shall be performed on all OLTCs and motor drive mechanisms. Over and above, pressure and vacuum tests shall be conducted as per IEC: 60214.

2) Type Tests

Type tests as per IS: 8468 shall be carried out on OLTC and 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 on a similar or higher rating OLTC and motor drive mechanism shall be submitted for Client's approval.

Additional Requirements

Tap position indicators and OLTC control switch shall be supplied loose if Client decides to mount the same in the power transformer control panel.

The finish and dimensions of the panel shall be as specified so as to match with the other panels in remote control room.

Fittings and Accessories

All transformers shall be supplied/fitted with following accessories as per relavant IS.

- Inspection cover,
- Buchholz relay with alarm and trip contacts (**for transformer ratings of 250kVA and above**),
- Marshalling box of IP 55 class of protection,
- Sampling valve with plug or cover plate,
- Magnetic oil level gauge and Plain oil level indicator with minimum mark,
- Conservator and conservator drain valve,
- Bi-directional rollers,
- Oil temperature indicator with alarm and trip contacts,
- Bottom drain and filter valve with plug or cover plate,
- Double diaphragm explosion vent,
- Silica gel breather,
- Air release plug/device,
- Separate neutral bushing,
- Top oil filter valve,
- Jacking pads,
- Lifting lugs,
- Two earthing terminals,
- Thermometer pocket for OTI,
- Winding temperature indicator with alarm and trip contacts,
- Pressure relief valve (**for transformer ratings of 200kVA and above**),
- Rating and diagram plate,
- Neutral CTs (NCT) for REF and Back-up E/F protection, differential protection (**for transformer ratings of 2000kVA and above**),
- OLTC and RTCC panel (**for transformer ratings of 2000kVA and above** if specified elsewhere in tender/SOQ),
- Oil surge relay (**only for transformers with OLTC**) and
- Any other required as per IS: 1180/IS: 2026

Accommodation for Auxiliary Apparatus

Where specified, Neutral CTs to be provided for the protection such as, restricted earth fault, back up earth fault and differential protection.

Rating Plates and terminal Plates

The followings plates shall be fixed to transformer in a visible position.

a) Rating Plate and Terminal marking plate shall be provided as per IS: 2026 Part:1/IS: 1180 Part:1 (2021).

Gas and Oil Actuated (Buchholz) Relay

Buchholz relay shall be provided with isolation valve on both the sides for transformers of capacity 250kVA and above.

The design of the relay mounting arrangements, the associated pipe work shall be such that mal-operation of the relays shall not take place under normal service. The pipe work shall be so arranged that all gas arising from the transformer shall pass through the gas and oil actuated relay.

The oil circuit through the relay shall not from a delivery path in parallel with any circulating oil pipe, nor shall it be tied into or connected through the pressure relief vent, Sharp bends in the pipe work shall be avoided.

All wiring connections, terminal boards, fuses and links etc. connected with gas actuated relays shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resistant insulation and the bared ends of stranded wire shall be sealed together to prevent seepage of oil entering connection boxes used for cables or wiring.

Cable Box/Bus Duct Box

Cable box shall not be mounted on the tank covers. It shall be feasible to remove the tank covers for inspection during maintenance etc. without recourse to breaking the joints or disturbing the cables already terminated. Necessary removable links in oil approachable through inspection cover in tank cover etc. after lowering oil shall be provided for test purpose. HV cable box shall be considered with disconnecting chamber.

Cable box entry shall be suitable for the size and number of run of cables. Gland plate shall be provided with required number/size of knockouts for cable terminations.

In case of bus duct, bus duct box of suitable type shall be provided.

In case of ACSR conductor connection on HV side, vertical bushing of suitable type and size shall be provided.

Parallel Operation

Transformers shall be suitable for parallel operation when explicitly mentioned in SOQ. For parallel operation of transformers, the transformers shall have identical percentage impedance, transformer (X/R) ratio, voltage ratio, vector group, phase sequence, polarity, phase angle etc. as minimum.

Tests

1) Tests at Works

All routine (Impedance voltage and load loss, no load loss and excitation current, applied voltage, induced voltage, resistance measurement, ratio tests, polarity and phase relation, insulation resistance leakage etc. tests) and other tests prescribed by IS: 1180 Part: 1 (2021) shall be carried out at the manufacturers' works' before dispatch of the transformers without any additional cost to the Client.

For all transformers **rated below 500kVA,** all routine tests as narrated above shall be carried out by the manufacturers' works' before dispatch of the transformers. Certified copies of test certificates shall be furnished to the Client/PMC/TPI for review and approval.

For all transformers **rated 500kVA and above,** all routine tests as narrated above shall be carried out in the presence of Client/PMC/TPI.

In addition to the prescribed routine tests, heat run/temperature rise test shall be invariably done on one transformer of each design for ratings of 2000kVA and above.

For trasformers with ratings lower than 2000kVA, temperature rise test certificate of identically rated transformer carried out as type test shall be submitted for review and acceptance.

In case, heat run/temperature rise test is to be carried out on transformers below 2000 kVA ratings, it shall be clearly specified in SOQ of the tender.

A copy of the impulse test certificate done on the same type/design of the transformer shall be furnished in accordance with IS for purpose of record. If no impulse test was done in an earlier unit of the same design and capacity, one transformer will be subjected to impulse test in consultation with the Client/PMC/TPI at Vendor/Contractor's cost.

Copies of the certificates for pressure test, bushings test and type test for short circuit shall be supplied to the Client/PMC/TPI for review.

Further if specified explicitely in SOQ/tender, one transformer of each type, design and rating approved from the project (tender) lot shall be selected randomly and sent to **ERDA** for determination/varification of losses. Costs incurred for such a test shall be paid separately as per SOQ. If values of losses so determined by ERDA, do not match with allowable maximum losses of particular rating, as specified in IS: 1180, such transformer shall be outrightly rejected and the Contractor shall replace the transformer without any additional cost to the Client.

2) Tests at Site

In addition to tests at manufacturers' premises, all relevant pre commissioning checks and tests conforming to IS code of practice No. 10028 (Part II and III) shall be done before energization.

The following tests are to be particularly done before cable joints or connecting up the bus bar trunking.

a) Insulation test between HV to earth and HV to MV with 5000V Megger.
b) Insulation test between MV to earth with 500V Megger.
c) Di-electrical strength Test on oil.
d) Buchholz relay operation by simulation test when fitted.

All test result is to be recorded and reports should be submitted to the department.

Installation and Commissioning

Fire protection system for transformers shall be provided as per CEA (measures relating to safety and electric Supply) Regulations/IE Act/Electrical Inspector. Separation walls or fire barrier wall shall be provided between the transformers as per the requirement. An oil soak pit/common burnt oil pit of adequate capacity with necessary valves/suitable pumping facility to keep the pit empty shall be provided as per applicable Standards/IE ACT/Regulations/Notification.

The transformer shall be installed in accordance with IS: 10028 (Part II and III) code of practice for installation and maintenance of transformer. Necessary support channels shall be grouted in the flooring.

The transformer shall be moved to its location and shall be correctly positioned. Transformer wheels shall be either locked or provided with wheel stoppers.

Transformer oil supplied in drums shall be topped up into the transformer after duly testing/filtering up to the correct level required.

Drying out of transformer winding will be necessary when the dielectric strength of the oil is lower than the minimum value as per IS: 10028 or the transformer has not been energized within 12 months of leaving the works or where the radiator assembly is done at site.

The transformer shall be dried out/filtration done by one of the methods specified in IS: 10028. Drying out with centrifugal or vacuum type filters will, however, be preferred. The contractor shall carry out the process of drying without interruption and shall maintain a log sheet indicating time, oil temperature and insulation resistance. BDV test shall be carried out and records to be maintained.

❖ SWITCHYARD and TRANSFORMER YARD WITH FENCING AND GATE

Fencing around the outdoor transformer substation/11 kV switchyard.

The fencing shall be at a distance of not less than 1.5 meter on all sides of the substation (pole structure and transformer plinths, as applicable) to ensure free movement all round.

Fencing shall be with GI chain links with proper MS angle supports. The posts shall be 75mm x 75mm x 6mm angle/channel of 3meter long. The post shall be 2.4 meter above finish ground level (FGL) and 0.6 meter below FGL, fixed in 1:4:8 cement concrete foundation of size 250mm x 250mm.

GI heavy duty chain link fencing panel of size 2meter width and 2meter height made from 50mm x 50mm angle frame and covering with GI wire chain mesh 75mm, 8 SWG. Cross support of GI flat of minimum 50mm x 6mm shall be provided diagonally in the frame. Frame shall be fixed to the post with heavy duty GI bolts.

A gate of minimum 3metre (2meter x 1.5meter) with GI heavy angle frame as above and with chain link fencing as per above details shall be provided with necessary access (road/pathway) for easy mobility of each transformers/vehicular movement and for ease of O and M of switchyard/transformer yard.

Minimum 2 hinges shall be provided on each side of the gate.

Two coats of Aluminium paint over a coat of Aluminium primer shall be applied on fencing post, fencing panel and gate. Final one coat of paint shall be applied after completion of work at site at the time of handing over.

Fencing and gates shall be installed as per site condition and actual requirement.

Fencing shall be earthed properly covering all rows on all sides. Fencing shall be connected to earthing grid though suitable size hot dip galvanized earth strip as specified else where.

Caution notice should be fixed one on the 2/4 pole structure and at suitable location near transformers and another on the gate.

The sub station shall be uniformly levelled after proper ramming. Brick soling of thickness 75mm including consolidating by proper ramming, providing 100mm thick layer of 1:3:6 cement concrete and then spreading 40 mm aggregate stone jelly of thickness 100mm.

The above shall be done for transformer yard and also 1 meter all around the fencing.

Transformer details like name of the manufacturer, rating, year of manufacture, date of charging etc. shall be painted on the fire wall at suitable location for clear visibility.

❖ LV PANELS: PCC/PMCC/MCC/APFC/LVDB/OTHER SWITCH BOARDS

Panel shall confirm to Indian Electricity Act and rules CEA Notification/Guidelines, CPWD guidelines 2019 as amended up to date and shall be as a minimum.

The LV switchboard/panels shall be floor mounting, free standing, compartmentalized, extensible, Modular type suitable for indoor installation. The panel shall be totally enclosed and dust, damp & vermin proof. Enclosure shall have IP 52 or better degree of protection for indoor unit and IP 55 or better degree of protection for outdoor unit as a minimum. Outdoor unit shall be double door and additionally provided with canopy or weather shed for protection.

Panel construction shall be complying to Form 3b type as per IS/IEC 61439 (i.e. separation of bus bars, all functional units and of terminals and external conductors etc. shall be as per Form 3b type as per IS/IEC 61439). Only metallic sheet shall be used for compartment separations/partitions. Hylam/PVC sheets shall not be allowed.

LV panels/switch boards sheet steel shall be CRCA minimum 2mm for load bearing members, mounting plate, partition, doors/covers, canopy. Gland plate shall be CRCA sheet minimum 3mm thick. All the doors and others openings shall be provided with neoprene rubber gaskets or of durable material gaskets.

All hardware shall be corrosion resistant. Star washers shall be used for effective continuity.

Suitable lifting arrangement with L angle welded at top for PMCC/MCC/APFC etc. shall be provided on each panel or on each shipping section for ease of lifting of switchboard.
A base channel of 100mm x 50mm x 5mm thick shall be provided at the bottom of the panel on all four sides of each shipping section.

Overall height of panel shall not exceed 2300mm (For VFD/Soft starter panel height up to maximum 2500 mm can be accepted) including minimum 100mm ISMC base frame. However, in case of panel mounted on floor without cable trench shall be mounted at least 500 mm above the floor level to provide adequate bending radius for in and out cables. Folding type stand of minimum height 500 mm with folding CRCA cover/sheet of 1.6mm thick all around the stand shall be provided. **Operational height of starters and control switch gear shall not exceed 1800/1900 mm above FFL (irrespective of overall height of panel) for ease of operation.**

Shipping section length shall be maximum 2500mm. Each shipping section shall have full side sheets of 2mm thick on both the sides. Vertical partition of incomer/bus coupler/outgoing feeders etc. shall be of full depth of the panel. Detachable gland plate shall be provided at the top on both the ends of the shipping sections for connecting/joining of bus bars.

PCC/PMCC panel shall have 2 numbers outgoing MCCB/ACB power feeders, one number on each side of BUS to feed power to downstream MCC panel.

All MCC feeders will have two incomers (one incomer as stand by) with electrical and mechanical interlocking between the two such that only one incomer is ON at a time.

Electrical interlocking mechanism shall operate in both Manual and Auto Operational mode without fail. Panel builder must ensure that proper fail safe interlocking in both modes is provided. SLD provided with tender documents is indicative and is for reference only. It is absolute responsibility of panel builder/integrator to desing the panel and ensure proper & satisfactory operation & performance of the offered panels and for satisfactory operation of plant / pumping station.

Minimum dimension of incomer, bus coupler, starter, MCCB cubical compartment shall be as per the Table. Height of main horizontal bus bar chamber shall be minimum 300mm up to 630A rating and 350mm

or higher for 800A and above. Vertical bus bar shall be minimum 300mm or higher as per kA level and temperature rise required. Minimum width of cable alley shall be 350mm or higher as per number of cables.

All type of meters shall be digital type. Ampere meter and voltmeter shall be single phase and separate selector switches shall be provided. Meter with inbuilt selector switches is also acceptable.
Control MCB shall be provided for control wiring circuit. Panel shall be of fuse less design.

CT on Y phase with digital ammeter to be considered from 7.5kW to less than 15kW motor feeders. 3 Nos. CTs with digital ammeter and ammeter selector switch to be considered for motors rated 15kW and above and less than 30kW. Digital multi function meters are to be provided for motors of 30kW and above.

RS 485 of all meters/MFMs shall be looped together inside the panel and brought out in the cable alley.

LV panel shall be of fixed type, single/double front. LV panel shall be single tier for incomers and bus coupler feeders rated 500A and above. Panels with VFD and soft starter feeders rated 22kW and above shall be in single tier only while the same shall be in single tier or two tier for less than 22kW VFD/soft starter feeders.

Outgoing ACB feeder of 1000A and above ratings shall be in single tier only.

Vacant space on incomer and bus coupler panel shall not be used for mounting the starter, switch gear modules, MCB feeder. Fixed capacitor/reactor may be housed below bus coupler with steel sheet separation/barrier.

VFD starter panel shall be stand alone panel in case of VFD for motors rating > 150kW. This provision does not apply in case of VFD panels to drive equipment like turbo blowers etc.

All auxiliary devices for control, metering, protection, indication and measurement such as push buttons, control and selector switches, indicating lamps, ammeters, voltmeters, kWh meters and protective relays shall be mounted on the front side of respective compartment, for easy operation without opening the door. Metering cubicle shall be separate/independent of ACB/MCCB incomer feeders.

Circuit breakers of required capability/suitability to interrupt applicable capacitive current shall be specifically verified/supported by manufacturers' recommendations.

The switch board components, bus bars etc. shall be designed to withstand the maximum designed short circuit level for minimum 1 second.

MCCB shall be TPN/4P, microprocessor based release/thermal magnetic release as specified elsewhere. All MCCBs shall be suitable for Ics = 100% Icu. The rated service short circuit breaking capacity (Ics) of MCCBs shall be more than or equal to the specified fault level. MCCB shall be supplied with extended rotary handle, terminal spreader, auxiliary C/O + trip contact as applicable.

Rating of MCCB/MPCB, contactors, relay etc. of motor feeders as recommended by equipment manufacturers' and shall comply with Type 2 Coordination as per IS: 60947.

Panel shall have main horizontal and riser bus bars, air insulated with coloured heat shrinkable PVC sleeves, housed in a separate compartment, segregated from all other compartments, with sheet steel barriers, sufficient louvers with wire mesh for air circulation.

The LV panels shall be provided with a continuous earth bus having sufficient cross section to carry the specified fault current for specified duration without exceeding the safe temperature throughout its entire length.

All control wiring except CT secondary wiring shall be carried out with minimum 1.0 mm² FRLS PVC copper flexible wires (Grey). CT secondary wiring shall be carried out with 2.5 mm² FRLS PVC copper flexible wires (Color coded).

Adequately rated anti condensation heater with porcelain connectors shall be provided in each breaker panel and in cable alley to maintain inside temperature 5 ^{0}C above outside ambient temperature. It shall be supplied from 240V AC auxiliary bus for space heater. The space heater shall be provided with a thermostat having variable setting of 30-70 ^{0}C and manually operated switch fuse and link for phase and neutral respectively.

All starters shall be provided with Auto-Off-Manual and Local-Remote selector switches (where start PB provided at panel end) to monitor and operate MCC or LCS, ICP/PLC.

All ACBs, MFM, VFD, Soft Starters where provided shall have inbuilt RS 485 port to communicate with PLC/SCADA for monitoring and control. RS 485 terminal shall be wired upto external TB with shielded wire.

240V AC control supply shall be fed from 415/230V AC constant voltage/control voltage transformer (with ± 2.5% and ± 5.0% tappings on both primary and secondary sides) one number on each bus of minimum 1.5 kVA rating (for less than 630 Amps connected load), and higher kVA rating depending on total connected working load. Suitable control logic through contactors shall be provided such that control supply is available to all feeders based on incomer 1 and incomer 2 status. Only one control transformer shall be ON at a time**. Separate control transformer 415/230V of suitable VA rating shall be provided for incomers. DP MCB of suitable rating shall be provided on both incoming as well as outgoing side of control transformer.** All CTs, PTs and constant voltage/control transformer shall be cast resin type with terminals. CT shorting link type control terminal shall be provided. Only Ring type lugs shall be used for CT termination.

2 Nos. auxiliary contactors to be considered for PLC interface.
All capacitors generally shall be at 440V or 525V if provided with detuned reactor or as specified in BOQ. Capacitors shall be heavy duty type with discharge resistors and with dielectric losses ≤ 0.2w/kVAR.

Adequate number of spare outgoing breaker/power feeders shall be provided in all panels/switchboards. At least one number of power feeder with highest rated outgoing breaker shall be provided as spare in PCC/PMCC and at least two numbers of 4 pole 63A rating (or higher rating or higher nos. as per Bidder's design requirement) shall be provided as spare power feeders in all panels/switchboards (PCC/PMCC/MCCs) as applicable (For PCC/PMCC the 2 numbers spare feeders shall be provided on each side of bus as a minimum). For PDB/LDB, minimum 2 numbers outgoing feeders of highest rating (for each phase) shall be provided as spare.

Following communication RS 485 Modbus, DI, AI and DO, AO to be considered for various type of feeder for PLC/SCADA interface.

	INCOMER (ACB/ MCCB)	**SOFT/VFD/SD STARTER (MPR)**	**MOV**
Communication	Inbuilt Modbus RS 485 for control and monitoring metering, energy and protection parameters (Applicable only for ACB)	Modbus RS 485 monitoring and control (SS and VFD) & MPR Only monitoring & Trip. In VFD: PF, energy saving also to be monitored.	-
Digital Input (DI)	Breaker ON/OFF	Motor Run	Valve Open
	Breaker Trip	Motor Trip	Valve Close
	Auto/Manual	Auto/Manual	Local/Remote
		Local/Remote	Trip/Fault

Digital Output (DO)	Breaker ON/OFF (latched type)	Start/Stop (latched type)	Valve Open
			Valve Close
Analog Input (AI)		Speed Feedback (Only for VFD)	Valve Position Feedback
Analog Output (AO)		Speed Reference (Only for VFD)	Valve Position Reference (Only for VFD)

In addition to above MFM and Temperature scanner with RS 485 Communication MODBUS shall be taken for interfacing with PLC/SCADA for monitoring and for controlling further as required.

Bus Bar

Bus bars shall be of high conductivity, electrolytic Aluminium (E91E) suitable for carrying the rated and short time current without overheating supported on insulators made of non hygroscopic, non flammable material to ensure free thermal expansion with tracking index equal to or more than that defined in IS.

Aluminium bus bars shall be sized for maximum 0.8 A/mm² current density only.
Whenever incoming supply is through bus duct, incoming bus bar of incomer shall be extended till the top end of panel and phase positioning/orientation of bus bars shall be suitable for transformer LV terminal arrangement to avoid additional phase cross over chamber.

Bus bars for risers shall be rated to carry minimum 80% or higher of the rated current of all feeders connected to the risers as per the design of the system/loading.

The current rating of neutral shall be minimum half that of phase bus bars. For LDB neutral rating shall be equal to that of phase bus bar.

Both horizontal and vertical TP and N, bus bars, bus joints and supports shall be capable of withstanding dynamic and thermal stresses of the specified short circuit currents for 1 second.

Only high tensile steel bolts, nuts and washers duly zinc passivated or cadmium shall be used for all bus bars joints and supports.

The hot spot temperature of bus bars including joints at design temperature shall not exceed 85 ^{0}C for normal operating conditions.

All bus bars shall be insulated with heat shrunk PVC sleeves of 1100V grade.

The bus bars shall be arranged such that minimum clearance between the bus bar for 50kA fault current shall be maintained as below.

- Between phases : 27mm minimum
- Between Phase and Neutral : 25mm minimum
- Between phase and Earth : 25mm minimum

To fulfill the requirement of 65kA for 1 second, necessary clearance as per relevant IS shall be maintained.

Auxiliary Supply Bus Bars

Auxiliary bus bar of **Tinned Copper EC grade** of suitable size shall run throughout the length of main busbar/vertical bus bar alley and supply shall be tapped to individual feeder directly from the bus and shall

not be looped between the feeders. Control MCB shall be provided for individual feeder. Auxiliary bus shall be provided for following applications. Exact size/capacity of bus bar shall depend on various controls, metering and auxiliary power distribution requirement.

- Panel space heater supply and motor space heater supply,
- Control supply for breaker tripping, closing and indication circuits,
- Control supply for breaker spring charging motors, motor starter control and indication circuits and
- AC potential supply for MFM, meters, starter and voltage operated relays etc.

Power and Control Wiring and Terminal Blocks

All wiring shall be done with FRLS PVC copper flexible wires with IS marks. The insulation grade for these wires shall be 660V grade. The control wiring shall be enclosed in plastic channels/Race way and neatly bunched together.

Control circuit wiring shall be FRLS PVC copper flexible wire of minimum 1.0 mm² size and CT circuit wiring shall be minimum 2.5 mm² size. CT wiring shall be R Y B colour coded and terminals shall be CT shorting link type only. Power wiring inside the starter module/MCCB/MCB shall be rated for full current rating of feeder MCCB/MCB.

All feeder modules shall be provided with neutral link. Suitable size and rating terminal blocks shall be provided for all outgoing feeders in the cable alley for connecting power and control cables. Cable shall never be connected directly to MCCB/MCB terminals.

Flexible wire shall be used only up to and including 100 A MCB/MCCB. For above 100 A MCCBs bus bar shall be used. Minimum size of FRLS Copper wire shall be up to and including 16A: 2.5 mm²; 20A: 4 mm²; 32A: 6 mm²; 40A: 10 mm²; 50A: 16 mm²; 63A: 25 mm². and 100A: 35 mm².

Each wire shall be identified at both ends by PVC ferrules. Inter panel wiring shall be done through rubber grommets. A minimum of 2 numbers or 20%, whichever is higher, spare terminals shall be provided on each terminal block.

Marking on the terminal strips shall correspond to wire numbers on the wiring diagrams. All spare contacts and terminal of panel mounted equipment and devices shall be wired to terminal blocks.

Earthing

The minimum earth bus size shall be minimum **65mm x10mm (hot dip galvanised strip) or 40mm x 10mm (Aluminium) or** higher to suit the fault level/kA requirement.

All doors and movable parts shall be earthed using minimum 1.5 mm² FRLS Copper flexible wires (Green colour) to the fixed frame of the switch board. Provision shall be made to connect the earthing bus bar to the plant earthing grid at two ends. All non-current carrying metallic parts of the mounted equipment shall be earthed. Minimum 4 numbers, 10 mm dia. hole shall be provided on the earth bus for termination of earth strip/wire.

Name Plate

Name plates shall be provided as per standards.
LV panel shall be with details like name of Client (on first row/top row), Project name (second row), name of Contractor (third row) and Panel builder/manufacturer (in fourth row) all with equal of descending order letters size on top of front side of panel.

LV panel shall be with name plate (on front side of door of incomer) having minimum details like (1) Power supply voltage, (2) Control supply voltage, (3) Frequency, (4) Panel fault level, (5) Panel protection class and (6) Panel manufacturing IS standards considered etc. details.

Painting

The LV panel shall be treated with seven tank/nine tank process with degreasing, water rinsing, De-rusting, water rinsing, phosphating, water rinsing, passivation.

After seven tank process the external paint shall be powder coated with Siemens grey RAL 7035 for inside and outside of LV panel.
Mounting plate shall be painted Glossy white.

Thickness of paint shall be between 100 Micron to 120 Micron.

Switchgear Modules

Air Circuit Breakers

Circuit breakers shall be air break, electrical draw out type for feeders 630A and above. All ACB shall be with microprocessor based release with overload, short circuit and inbuilt earth fault protection. Only for APFC incomer thermal magnetic type can be accepted.

The ACB shall be minimum 50kA (1 Second) or higher as per fault rating, I_{CS} = 100%$I_{CU=}$ Icw. All ACBs shall comply and tested as per IS: 13947/IEC 60947-1 and IEC 60947-2 standards.

ACB for all incoming, Bus coupler should be Four Pole Type. PCC outgoing feeders shall be Four Pole/Three Pole + Solid Neutral (TPN) Type.

ACB for incoming and bus coupler shall be identical and interchangeable.

ACB models shall be: **Schneider: Master pact NW, Siemens: 3WL, L & T: U power, ABB: E-Max; or Equivalent** model from Approved Vendor list. Data sheet with parameter comparison shall be submitted for approval.

ACB shall be with **inbuilt Communication Module** RS 485 for MODBUS for communication with SCADA/PLC for both control and monitoring.

Electrical and mechanical interlocking shall be provided between ACB incomers and bus coupler with required key locks, under voltage coil etc. as per the system requirement. Only ACB auxiliary built-in contact shall be used for interlocking i e auxiliary contactor/plug-in relay shall not be used.

ACB Trip Release LSIG (Micro Processor based) should have minimum as following.

- Overload with time delay
- S/C with time delay and instantaneous trip setting
- Earth fault with time delay
- Under/over voltage for incomer
- LSIG fault record display (Only For Incomer and Bus coupler)
- Metering and Energy display (Only For Incomer and Bus coupler)
- Ammeter display (For Outgoing feeders)

ACB shall be fitted with following.

- Auxiliary built-in contacts having not less than 4 NO + 4NC contacts
- Built in resin cast current transformer
- Shunt and under voltage tripping device
- The ACB shall be suitable for locking the breaker in various positions. Interlocks shall be provided to: Prevent the breaker from being isolated unless it is in the 'OFF' Position; Prevent the breaker from being racked in to the service position unless it is in the 'OFF' position; Prevent the breaker from being accidentally pulled completely 'OFF' the guide rail.
- Safety shutters of an insulation material shall be provided to prevent access to all live contacts, when the breaker is in the inspection position or completely withdrawn.

Moulded Case Circuit Breakers (MCCB)

All MCCBs shall be comply and tested as per IS: 2516/IEC 60947-1 and IEC 60947-2 standards.
Incomer MCCBs shall be 4 P, 50kA or higher (and Ics = 100% Icu) with micro-processor based release with in built O/C, S/C and E/F protection.

Outgoing MCCB TPN for power feeders up to and including 200 A shall be with thermal magnetic release with adjustable O/L and Adjustable/Fixed S/C protection. Outgoing MCCBs from 250 A and above shall be with microprocessor based release with in built Adjustable O/C, Adjustable S/C and Adjustable E/F protection.

All MCCBs shall be 50 kA or higher, Ics = 100% Icu and with extended rotary handle and terminal spreader. Auxiliary change over contact 1 No + 1 NC and trip contact shall be provided as per the requirement.

MCCB of Soft Starter/VFD feeder shall be TPN with microprocessor release with overload/short circuit and inbuilt earth fault release.

MCCB as part of DOL/Start Delta motor starter module shall be current limiting type, TPN, (rating and protection type as indicated above) and type tested for Type 2 Coordination as per IS: 13947/ IS/IEC: 60947.

MCCB models shall be: **Schneider: NSX/CVS** (for ≥ 250 A) and **CVS** (for ≤ 200A) or **Siemens**: 3VL or **L & T**: D Sine or **ABB:** T-Max; or **Equivalent model** from approved vendor list.

Electrical interlocking shall be provided between MCCB incomers and bus coupler with required under voltage coil, auxiliary contactors as per the system requirement.

Switches/Fuses

The switches or fuse switches shall be load break, heavy duty/motor duty, air break type provided with quick make/break manual operating mechanism. The operating handle shall be mounted on the door of the compartment having the switch. Fuses shall be non-deteriorating HRC cartridge link type.
Rating of heavy duty switches or motor duty starter modules shall meet the requirement of AC23 duty as per IS: 13947.

Contactors

The contactors shall be air break type, equipped with three main contacts and minimum (2 NO + 2 NC) auxiliary contacts. All contactors shall be 3 Pole, AC3 duty except for lighting feeder where in the contactor shall be 4 P and AC1 duty. External by pass contactor used for soft starter shall be AC1 or AC3 as recommended by soft starter manufacturer.

Unless otherwise specified, the coil of the contactor shall be suitable for operation on 240V, 1 Phase AC supply and shall work satisfactorily between 65 to 110% of the rated value.
Contactor used for capacitor feeder shall be capacitor duty contactor with inbuilt leading contact with wiper function for limiting/damping the capacitor inrush current with NO NC Auxiliary contact.

Bimetal Relay

All bimetal overload relays shall be with in-built single phasing prevention and with Manual/Auto reset type (selectable) with at least 1 NO and 1 NC contact with reset type push buttons in the front, mounted on door such that it shall be possible to reset the O/L relay without opening the compartment door.

Motor Protection Relay (MPR)

Motor Protection Relay (MPR) shall be provided for 30kW and above and only for star delta starters. MPR is not required for VFD/Soft starter motor feeders.

Motor protection relay (MPR) shall be numerical type with over load, short circuit, earth fault, under current, unbalance, phase loss/reversal, stall, locked rotor, no load running.

Single phasing prevention with adjustable under/over voltage protection shall be provided separately if the same is not inbuilt feature in MPR.

MPR shall be Numerical with adjustable parameter with inbuilt MODBUS over RS 485 interface if specified in SOQ/elsewhere in the tender. **MPR shall be DIN rail mountable base module and LCD display module shall be panel door mountable. ZCT/CBCT shall be provided for earth fault/ leakage protection (range 0.1A to 2A). It shall have programmable 2 DI and 2 DO.**

MPR shall display 3 phase current, unbalance 9% as minimum and earth current monitoring.
MPR shall store fault records/Start- Stop records/motor run hours/maximum starting current etc.
For motors 30kW and above external CT (3 nos) 5A, Resin cast of suitable VA shall be used.
Make: **C & S mPRO 200 with ZCT or equivalent model** of other approved makes. Data sheet with parameters comparision shall be submitted for approval.

Motor Starter

DOL starter to be considered for rating less than 7.5kW rating. Star-delta starter is to be considered from 7.5kW rating and upto less than 75kW rating. Soft starter to be considered for 75kW and above ratings.

VFD shall be provided for any rating if specifically asked for/as per the requirement/application.
Soft starter shall be provided for lower ratings also if specifically asked for/as per the requirement.

MCCB rating upto 800A as incomer for Soft starter and VFD starter is acceptable.

MPCB with overload protection, short circuit protection and single phasing/phase loss protection, AC3 duty contactor for DOL feeders and Start Delta feeders up to and including 15kW.

All MPCB shall be with rotary switch.

MCCB (with adjustable overload, adjustable short circuit, earth fault) microprocessor release or thermal magnetic release (with adjustable overload, adjustable/fixed short circuit) as per MCCB rating, AC3 duty contactor, numerical motor protection relay as applicable, A/M switch, L/R switch, indicating lamps, push button etc. shall be provided.
Provision for door mounting PMU shall be provided in the starter cubicle of submersible pump motor. Wiring shall be done up to terminal connector for PMU input from field.

Minimum 8 channel or higher, temperature scanner shall be provided in starter feeder for 90kW and above rated motor feeders wherever motor is supplied with RTD and BTD.

Temperature scanner/Thermister and PMU (as applicable) shall be interlocked with starter feeder with control/tripping circuit of starter feeder. Temperature scanner shall be door mounted. Soft starter/VFD shall be with input terminal for RTD (PT 100) and Thermistor for motor temperature (winding and bearing) monitoring/protection.

Temperature Scanner

Temperature scanner of required cahnnels with minimum 2 spare channels shall be provided to detect high winding, and bearing temperature in order to generate tripping signals. The input signals to temperature scanner shall be derived from the motor. Industrial type PT 100 resistance temperature detectors shall be provided in the motor windings and bearings.

1	Service and type	Motor winding and bearing temperature measurements – microprocessor based
2	Range	0 to 200 ^{0}C
3	Alarm Contacts	Adjustable 4 Nos. (high temperature and very high temperature) for motor winding and bearing
4	Type of Relay contacts	One Single Pole Double Throw per set point (Relay)
5	Input Signal	From RTDs for each Motor winding and bearing winding
6	No. of channels	6 Nos. for Winding + 2 nos. Bearing + 2 Spare
7	Accuracy	$\pm$ 1 ^{0}C
8	Communication	RS 485 for Instrumentation panel interface if specified to be provided in SOQ/elsewhere in the tender.

Instrument Transformers (CTs/PTs)

Current transformer and potential transformer shall generally conform to IS: 2705, IS/IEC: 60044-122 and any special requirement with reference to numerical relay shall be taken care of by contractor. All CTs shall be resin cast type and secondary 5 A. APFC feedback CTs, MFM CTs, MPR CTs shall be of Class 0.5 and 10 VA. CTs (80A and above) of digital ammeter, APFC panel metering shall be Cl. 1 and 5 VA. CTs less than 80A shall be Cl 1.0 and 2.5 VA.

The current transformers in breaker feeders shall be capable of withstanding the applicable peak momentary short circuit and the symmetrical short circuit current for 1 second.

Indicating/Measuring Instruments

The meters shall be digital type and generally of square pattern type of 96mm x 96mm suitable for flush mounting. Instrument shall generally conform to IS: 1248 and shall have accuracy class of 1.0 or better. Digital meters shall have 3 line, 3 ½ digit, LCD display as a minimum.

All auxiliary equipment such as shunt transducers, CTs, PTs etc. as required shall be included in the supply of panel/switch board.

The current coil of ammeters and potential coils of voltmeters shall continuously withstand 120% of rated current and voltage, respectively, without the loss of accuracy.

Digital ammeter and voltmeter shall be with separate selector switches instead of meters with inbuilt selector switches. Ammeters and voltmeters with built in selector switches are not acceptable.

Digital type multi function meter shall be with 3 line display, accuracy class: 0.5 suitable for measuring and displaying the following parameters: A, V, F, PF, kW, kWH, kVA, KVAR, KVARh, Md (for PCC/PMCC incomer feeder MFM only), Harmonic and with inbuilt RS 485 communication port. (**Schneider**: EM 6400NG; **L & T**: MFM 4420; **Secure**: Elite 443; equivalent model of other approved make). Data sheet with parameter comparison shall be submitted for approval.
MFM shall be provided for all incomers (PCC/PMCC), all motor starter feeder rated 30kW and above and all outgoing power feeders of PCC/PMCC rated 100A and above. For motor starters and outgoing power feeders provided with MFM, separate ammeter/voltmeter/PF meter is not required.

Push Buttons

Push buttons shall have rated operational current of not less than 4A (AC 11).
Push buttons for START, OPEN, CLOSE, LEFT, RIGHT, FORWARD, REVERSE etc. shall be flush type with spring aided self reset contacts.
Push buttons for STOP/EMERGENCY STOP shall be mushroom headed type with stay put contacts and shall be coloured red. The operation of the button shall be press to lock and twist to release.
The stop PB for each outgoing feeder/starter at MCC and for field LCS shall be EMERGENCY STOP push button. Push buttons shall be in compliance with IEC 60947-5-5.
Illuminated PB is also acceptable.

Push Button

Colour of push buttons shall be as follows.

Stop/Open/Emergency	:	Red
Start/Close	:	Green
Reset/Test	:	Yellow/White

Indicating Lamps

Colour shade for the indicating lamps shall be as below LED type.

ON indicating lamp	:	Red
OFF indicating lamp	:	Green
TRIP indicating lamp	:	Amber
PHASE indicating lamp	:	Red, Yellow and Blue
TRIP circuit healthy lamp	:	Milky

Fixed Compensation

Fixed capacitor banks for transformer compensation (for no load as well as leakage reactance) shall be provided. MCCB 50kA or higher as per specifications along with ammeter, CT 3 nos, capacitor duty contactors, ON delay timer, heavy duty multiple capacitor units (in smaller kVAr ratings viz 10,5,2,1) totaling to 5% value of transformer rating. Capacitor shall not be mounted below incomer feeder. Capacitor, if provided below bus coupler, capacitor housing/compartment shall be fully separated with steel sheet. Proper ventilation shall be provided.

7% detuned reactor with thermostat, 440V shall be provided in series with 525V capacitor or as per SOQ, if working VFD load is more than 50% of total load or if specified in SOQ. kVAr rating of capacitor shall be suitable for reactor rating.

For Capacitor banks of ratings > 50 kVAr for transformer fixed compensation, separate enclosure shall be provided. Fixed capacitor banks meant for transformer compensation for ratings > 50 kVAr shall not be

permitted to house in main LV PMCC/PCC panels. Only 4P MCCB power feeder shall be provided in PCC/PMCC panel for the same.

Danger Notice Plates

The danger notice plate shall be affixed in permanent manner on operating side of the panels. The danger notice plate shall indicate danger notice both in Hindi and English and local language with a sign of skull and bones as per IS: 2551.

Shop Drawings

Prior to fabrication of the panels the panel builder/vendor/contractor shall submit documents consisting of technical data sheet (duly filled), GA drawings, GA drawings with front door open with mounting plate details and equipment, sectional elevation, single line diagram, power/wiring drawing, bill of material etc. including design calculations indicating type, size, short circuiting rating of all the electrical components used, bus bar size and calculation, power/control wiring size, panels dimensions, colour, mounting details etc. in 5 sets for PMC/TPI's approval.

The contractor shall submit manufacturers' technical catalogues of major items like ACB, Soft Starter, VFD, MPR of offered makes/models for approval along with above documents.

Soft Starter/VFD selection indicating rated full load current, de-rated current for design ambient temperature, full load current of motor, 110% rated full load current of motor as per IS: 12615 shall be given by SS/VFD OEM. De-rated current of SS/VFD shall be equal to higher than 110% full load current of motor as per IS: 12615/SOQ. Power drawing and control drawing of SS/VFD shall be got vetted from SS/VFD OEM before submission of drawings.

Test Certificates

Testing of panels shall be carried out at factory as specified in Indian Standards in the presence of Client/PMC/TPI. The test results shall be recorded on a prescribed form. All type test certificates and routine test certificate for the test carried out at factory and bought out material and at site shall be submitted in duplicate to the consultant for approval.

Cubicle/Feeder Size Criteria For LV Panels

ACB Minimum cubicle compartment size considering minimum height of 1800 mm.

ACB Rating	**Width of Compartment (I/C or O/G) (mm)**	**Width of Compartment (Bus Coupler) (mm)**	**Depth (mm)**	**Remark**
630 A – 1250 A 4P	800	900	1000	Cable entry
1600 A 4P	900	1000	1000	Cable entry
2000 A - 2500 A 4P	900	1000	1200	Bus duct entry
3200 A – 4000 A 4P	1100	1200	1300	Bus duct entry

NOTE: Dimension mentioned above is minimum. Height of ACB feeder shall be 1800 mm excluding main Bus bar chamber. Above 1000A ACB outgoing feeders shall be in single tier. Up to and including 1000A ACB outgoing breaker feeder shall be in single/double tier.

MCCB Minimum cubicle compartment size.

MCCB Rating	Width of Compartment (mm)	Height (mm)	Remark
Up to 100A	350	300	Copper flexible shall be used
125A – 200A	400	350(3P)/400(4P)	Bus bar/strip
Above 200A to 400A	500	450	Bus bar/strip
Above 400A to 550A	600	500	Bus bar/strip
Above 550A	600	600	Bus bar/strip

NOTE: Dimension mentioned above is Minimum. Depth of panel as per required depending on cable size/ site condition and for ease of maintenance.

VFD and SOFT Starter Minimum cubicle compartment size considering minimum height of 1800mm.

Motor Rating	Minimum Width of Compartment (For VFD and for Soft Starter with External Bypass Contactor)	Minimum Width of Compartment (For Soft Starter with Built in Bypass Contactor)	Depth of Compartment
Less than75 kW	700	700	800
75 kW to ≤ 132 kW	800	750	900
Above 132 ≤ 250 kW	900	800	900
Above 250 kW	1000	900	1000

NOTE: Dimension mentioned above is minimum. S/S and VFD feeder for 22kW and above shall be in single tier only.

- **AUTOMATIC POWER FACTOR CONTROL PANEL (APFC PANEL)**

APFC panel shall be floor mounting, free standing, compartmentalized, extensible, modular type suitable for indoor installation.

The panel shall be IP 52 for metering and switchgear module and shall be IP 42 for reactor/capacitor section. Full partition shall be provided between switchgear components and capacitor section. Each feeder module shall be fully compartmentalised. Capacitor/reactor shall be mounted in separate vertical section/cubicle adjacent to switchgear cubicle instead of mounting at the rear end/backside of switchgear module as per availability of space.

The control equipment including capacitors shall be mounted in panel made of 2mm CRCA sheet. Panel shall be fully compartmentalised, extensible and with main bus bars in horizontal bus bar alley.

Capacitor feeder rating shall not exceed 100 kVAr rating.

Ammeter, ammeter selector switch and CT shall be provided in 50 kVAr and above rated feeders to measure capacitor current.

APFC panel control logic shall be such that when DG is ON, APFC panel shall be OFF and shall become automatically ON when the Grid power/utility power is restored.

The fixed capacitor bank will be provided on each incomer, as applicable, on upstream side of incomer breaker. Adequate arrangement of interlocking between APFC panel and transformer fixed

compensation power capacitor bank for no load power factor improvement must be made in such a way that during load condition i.e. when associated incomer breaker is ON and downstream load is working (load / current is being sensed above certain threshold), the fixed compensation capacitor bank shall be switched off. Similarly, when incomer breaker is OFF or the downstream load are OFF (load / current is zero / below certain threshold), the fixed capacitor banks shall be ON i.e. in functional/working mode. The objective of this interlocking arrangement is to compensate for p.f. during no load condition and it shall also be ensured that power factor does not go into leading side when pumping system is not running / plant under no load condition. For this purpose the fixed capacitor bank shall be adjusted / fine tuned at site to decide the required kVAR to be kept ON out of total and same will be reviewed and set from time to time periodically.

APFC panel shall be operated on AUTO and MANUAL mode. Individual capacitor feeder shall be possible to be operated on AUTO/MANUAL mode even when A/M switch in incomer feeder is on AUTO Mode.

All capacitors shall be heavy duty MPP/Heavy duty Gas filled with discharge resistor and as per the technical data sheet provided here in. However in case of only smaller capacity ie < 5 kVAr, APP type capacitors are also acceptable.

Heavy duty exhaust fan 6"/8" (shall be continuous duty, metal housing with metal impeller) with canopy shall be provided at the top. Louvers with wire mesh (up to maximum 1mm opening) shall be provided at the bottom end of capacitor section. Minimum 1 number of fan shall be provided per meter length of panel or part thereof or more numbers as required.

Minimum distance between two capacitors and from all sides of panel enclosure (including terminal) shall be 25mm.

Earthing terminal of capacitor shall be connected to earth bus bar.

Automatic Control Panel and Fixed Capacitor Panel (for Transformer Compensation) shall comprise following.

MCCB for protection of each capacitor bank (MCCB should be suitable for capacitor switching and kA rating shall be as per main panel kA rating). For smaller ratings of capacitors ie < 10 kVAr only D curve MCBs of appropriate ampere ratings are acceptable.

Incomer MCCB shall be TPN, microprocessor based/thermal magnetic (adjustable O/L and Adjustable S/C) as per LV panel specifications.

APFC relay shall be microprocessor based with inbuilt RS 485 for sensing and correcting the power factor of the system with required number of steps to achieve the specified power factor. Minimum steps of power factor relay shall be 10 or as per SOQ. Minimum operating current/sensing current shall be 10 mA/10% of load. Minimum 2 numbers additional spare relay contact shall be available for future use.

Two numbers vacant feeders with mounting plate and cutouts shall be provided for future use.
A/M switch with Auto/Manual indicating lamps shall be provided in addition to R Y B indicating lamps.
Each outgoing capacitor feeder shall be provided with suitably rated MCCB, capacitor duty contactor with inrush damping resistor, A/M switch, 'ON' and 'OFF' push with ON, TRIP, AUTO indication lamp, ON delay timer (only for Manual mode of individual feeder), 440V capacitor unit with discharge resistor.

Control circuit of individual feeder shall have control MCB for protection and indicating lamp shall be only through auxiliary contact.

All outgoing MCCB feeders shall be 50kA, Ics = 100% Icu, with trip indication/fault signal contact, with extended rotary operating handle, any other components required for satisfactory and safe operation shall be provided.

Capacitor shall be compact in size and hermetically sealed. In built fuses and surge suppressors shall be provided for protection of each capacitor element.

Capacitor banks shall comprise identical delta connected three phase units. Capacitor banks shall be non-flammable, non-toxic, non-PCB, dry technology, inert gas (N_2)/PU resin impregnated, MPP heavy duty type/Gas filled.

Only one wire shall be connected to each contactor terminal i.e. whenever more than one capacitor is controlled from contactor suitable size bus bar strip shall be provided and power shall be tapped. Else separate contactors shall be used for each capacitor unit.

If load is VFD driven and working VFD driven load is more than 50% of total load, or if required or specified in SOQ, APFC panel shall be with detuned reactors. 7% detuned reactor, 440V, Al. wound with thermostat shall be provided in series with capacitor unit. Capacitor voltage shall be 525V or as specified in SOQ and kVAr rating suitable for reactor kVAr rating. Filter rating (Reactor + Capacitor) shall be rating of APFC panel.

Except for the specific requirements of APFC panel specified here in, rest all specifications shall be as per LV panel/switchboard specifications specified herein.

Capacitor rating generally shall be at 525V if provided with detuned reactor or as specified in SOQ and APFC Panel shall conform to IS: 16636 (2017).

Three Phase Filter Reactor

Anti resonance three phase filter reactor, Aluminium wound, 440V detuned reactors (5.67% or 7%) as required are to be used in series with shunt capacitors to prevent harmonic resonance and harmonic overloading of capacitors, transformers, whenever power electronic equipment (Drives, UPS etc.) producing nonlinear currents are used. Detuned systems shall be such that the self resonant frequency is below the lowest line harmonic.

Features of Reactors

- High linearity, low losses and noise level
- High over loading capability
- Inbuilt temperature micro switch

Micro switch potential free contact shall be used in control circuit of respective capacitor feeder to trip the contactor in case of high temperature.

Reactor shall be kept in independent cubicle and adequate ventilation shall be provided.

Power Factor Correction Thyristor Switch Module

Thyristor switching instead of contactor switching shall be used when load variation is rapid. Semi conductor fuses shall be used for protection of Thyristor switches in addition to MCC, BHRC fuses shall not be used. Discharge reactors shall be used for fast discharge for fast reconnection of capacitor.

Technical Features

- Suitable for real time power factor correction
- Switching time less than 5 milli seconds
- PIV: 2200
- Permanent self controlling of voltage parameter, capacitor current, temperature of the thyristor switch
- Suitable for manual operation also
- Automatic switch off in case of over current and over temperature
- Display of: Operation, Faults, Activation.

APFC Controller with RS 485

Microprocessor based intelligent control, menu driven, single/3 CT sensing, 5A CT selectable with RS 485 communication port and features as below.

- Display: LCD illumination, large and multi functional characters.
- Parameters: Voltage, monitoring of individual capacitor currents, Real time PF, Power kW, kVA, kVAr, Temperature, Energy KWh, KVAh, KVARh
- Steps: 4, 6, 8, 12,16 as required
- Mounting: Panel mounting (size: 144mm x 144mm)
- Current input: 1 A or 5 A selectable
- Operating temperature: 0 to 60 ^{0}C
- Supply voltage: 230V AC
- Target PF: 0.8 inductive - 0.8 capacitive.
- Minimum operating current: 10 / 50 mA
- Sensing: Single/3 CT, 3 CT sensing for unbalanced load.
- Dual target power factor setting: for utility and DG mode operation.
- Facility of including "Fixed capacitor bank" for purpose of transformer compensation. This can be set such that the controller doesn't 'see' this capacitor.
- Potential free contacts/alarm output: Insufficient compensation, over compensation, under current, over current, over temperature, harmonics exceeded.
- Suitable for Thyristor switching if Thyristors are used instead of contactor.

Minimum rating of MCCB, Cable/flexible wire size for capacitor feeder shall be as below.
Cable Size Selection Chart (Minimum)

Sr. No.	**Capacitor Rating (KVAr)**	**MCCB Rating (Amps)**	**FRLS Copper Cable/Wire size (mm²)**
1	Up to and ≤ 5	16 **(MCB Acceptable)**	2.5
2	10	32	4
3	12.5	32	6
4	15	63	6
5	20	63	10
6	25	63	16
7	30	100	25
8	40	125	35 mm²/Bus bar from bus to MCCB
9	50/60	160	50 mm²/Bus bar from bus to MCCB
10	75	200	70 mm²/Bus bar from bus to MCCB

CAPACITOR DATA SHEET

Sr. No.	PARAMETER	Unit	
	Capacitor Type		Heavy duty MPP/Heavy duty Gas Filled
1	Conformance to Standards		IS: 13340/IEC 60831
2	Rated Voltage	V	440/525 as required/Applicable
3	Inrush Current	A	Up to 200 Ir
4	Maximum Permissible Current/ Over Current	A (Imax)	1.5 Ir
5	Maximum permissible Voltage/ Over Voltage	V (Vmax)	1.1 Vr
6	Temperature Class	^{0}C	60
7	Losses (per phase)	W/kVAr	Dielectric: less than 0.2 Total : less than 0.5
8	Capacitance Tolerance		-5% / + 10%
9	Dielectric		Poly Propylene
10	Impregnation		Non-PCB PU Resin/Inert Gas Nitrogen
11	Number of Switching Operation		5000 as per IEC 60832
11	Useful Life	Hours	125000 Minimum
12	Maximum THD in Voltage		3%
13	Maximum THD in Current		15%

Note: Rest all construction features and other requirements shall be as per specifications of LV Panel.

Test and Test Reports

All tests shall be conducted in accordance with the latest edition of IS: 2834 and as applicable for controls. Type test certificates for similar capacitor units shall be furnished for review and acceptance.

Drawings to be submitted for the approval of the Client/PMC/TPI

- GAD with elevation, side view, sectional view and foundation details.
- Complete schematic and wiring diagrams.
- Detailed BOM and GTP.
- Manufacturers' technical data sheet of capacitors and APFC relay.

❖ SOFT STARTER (FORMING PART OF LV PANEL) OR STAND ALONE PANEL

Scope

This specification covers the requirement for design, manufacture, installation, testing and commissioning of step-less reduced voltage/solid state torque controlled soft starter for motors in MCC panel to provide linear ramp starting and stopping of AC induction motors.

Constructional and Performance Features (Microprocessor Soft Starter)

The PCB power structure shall consist of six SCR's mounted on a heat sink for ratings up to suitable rating of motor. PCB shall be self tuning to accept control power input as per design.
Soft starter shall have current transformer/sensor in all the three phases for current monitoring.
All phases should be controlled during start/stop.
Soft starter shall consist of built-in RS 485 MODBUS RTU for monitoring and control through PLC/ SCADA.
Soft starter should be built for continuous operation without need of by pass for any reason.

Soft starter shall have features which allows the soft starter to operate with only 2 controlled phases in case of short circuit of 1 set of thyristor avoiding unplanned stop and possibility to keep running motor until the softstarter is repaired.
Control terminals shall be easily accessible and located on the front bottom of the device.

Sizing/Selection Criteria for Soft Starters

Soft starter de-rating factor for selection of soft starter shall be based on design ambient temperature (50 ^{0}C), altitude (up to 1000 m above MSL as standard or higher as per site requirement) etc. declared by OEM as % de-rating in their published catalogue available in the PUBLIC DOMAIN only. Rating/model selection based on design software/certificate issued by OEM will not be acceptable/considered for selection.

Further the soft starter shall meet following conditions to be confirmed by soft starter manufacturer/ OEM.

Start Current (cold start)	:	400% of In (rated current of motor) for 20 seconds (Class 20 Tripping Class)
Starting Frequency	:	Up to 10 number of starts per hour

Following shall be considered while sizing the soft starter and its enclosure.

Soft starter shall be de-rated as per manufacturers' recommendation for 50 ^{0}C operating conditions based on site/operating condition and such de-rated current of soft starter shall be minimum 110% of full load current of motor as per IS: 12615 (latest edition) or as per SOQ.

Soft starter shall be rated for DOL starting and shall have **In-built/External Bypass** contactor of AC1 or AC3 rating as recommended by soft starter OEM.

Soft starter shall be provided with breaker (MCCB/ACB) along with fast acting semi conductor fuse protection, with fuse base and with series contactor of required rating as recommended by OEM.

Soft starter signal to be interlocked with PLC and in manual mode timer based interlock to be provided to ensure that signal to turn on soft starter is fed only if contactor close signal is received to switch off supply to contactor through PLC when soft starter is not ON.

Contractor/Vendor shall furnish the heat dissipation load data and shall provide the cooling arrangement accordingly to ensure that the temperature rise within enclosure does not exceed 5 ^{0}C over the maximum ambient temperature of 50 ^{0}C.

Minimum two cooling fans shall be provided or higher number as required. Cooling fan shall be continuous duty, metal housing with metal impeller, minimum 6" size (minimum 8" for 160kW and above). The enclosure cooling fans and temperature sensing device (RTD/Thermisters) with tripping arrangement shall be provided and shall also be interlocked with soft starter operation i.e. in case of cooling fan failure or excess temperature (55 ^{0}C or as set), the soft starter shall be tripped/shall not turn ON.

Vents for air suction into panel shall be provided with louvers with filter (front washable and replaceable). However for 160kW rating and above vents shall be Louvers with wire mesh (up to maximum 1mm opening) an in this case enclosure shall be genrally with IP 42 proteciton class.

Soft starter shall be provided with conformal coating according to IEC 60721-3-3 to withstand harsh environment.

Auxiliary contact of incoming breaker and contactor shall be used in series to provide "Soft Starter Ready" interlock signal for PLC/remote operation

Detachable display/key pad with digital parameter adjustment, preferred with cable suitable for door mounting. The control key pad and display shall have the option for remote mounting. For safety reasons the controller should have green lights for running and red for start/stop.

Enclosure/panel shall be generally as per IP 52 protection.

Control Module Design Features

User Adjustments

The acceleration start ramp and stop ramp timers shall have minimum individual adjustments from 1 to 60 seconds.
The initial torque setting shall be adjustable from 0 to 200% of motor torque.

The end torque setting shall be adjustable from 50 to 200% of motor torque.
Current limit starting shall be adjustable from 150% to 500% of the motor's full load current.

Pump Control (Standard Feature)

The standard feature pump control shall be implemented to provide closed loop control of motor to match the specific torque requirements of centrifugal pumps for both starting and stopping.

Pump stop shall be initiated without the need for a dedicated pump stop input. A coast-to-rest stop shall still be possible with stop input.

Controller's Features and Modes

a) **Starting modes** required for controller includes linear torque control for Start, Pump Control Current Limit Start (Voltage Ramp Start, Voltage Ramp with Current Limit Start, Full Voltage DPL Start, Soft Start with Selectable Torque Boost etc.), Bypass Control and Bypass Contactor mode with all the protection parameter working.
b) **Stopping modes** required for controller includes linear torque control for Stop, Pump Control (DOL/Coast to stop), Bypass Control, DC/Dynamic brake for fast stop of motor with high moment of inertia etc.

Protection and Diagnostics

Protections of Controller shall meet applicable standards.

Protective Features

Motor Thermal Overload–selectable for starting class 10A, 15A, 25A under load protection (to avoid dry run), Soft Start thermal overload, PTC input, Phase imbalance, Phase reversal, Over voltage, Under voltage, Locked Rotor, Excessive Starts per hour for application, Phase loss input/output etc.

Electronic thermal memory shall be provided for enhanced motor protection.

All Protections should be available in bypass mode also.

When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.

Soft starter shall preferably be with input terminal for RTD (PT 100) and Thermistor for Motor Temperature (winding and Bearing) monitoring/control/protection.

Fault Indications

Controller shall indicate latest fault indications/occurrence for: Line failure, Phase imbalance, Over temperature: motor, Over temperature: Soft Starter, Shorted Thyristor, Open Thyristor, Locked Rotor, Motor output loss, Overload and Under load – Shaft Torque, Over voltage, Under voltage, Excessive Starts and Phase reversal etc.

Viewing Functions

Motor Current, Three Phase Voltage, Shaft Power in kW/HP (selectable), Motor thermal capacity, Motor Energy consumption (kWh), Power factor, Run time in hours etc.

Soft starter model shall be: **Schneider: ATS-48, ATS-480; ABB: PSTX; Danfoss: MCD600** or equivalent model of **Siemens** or **Rockwell** or additional vendor from approved vendor list.

Notes:

1. For soft starter standalone panel, rest all construction features and other requirements shall be as per the specifications of LV panel.
2. The soft starter features specified are in general and any manufacturer specific deviations in certain features can be reviewed and accepted based on merit/application requirement.

❖ VARIABLE SPEED (VFD) AC DRIVE SYSTEM AND VFD STAND ALONE PANEL

General Requirement/Specifications

Variable frequency drive (VFD) system shall consist of all components required to meet the performance, protection, safety and testing and certification criteria of this specification. These components may include harmonic filter/ power factor correction unit, input transformer, VFD converter/DC-link/inverter and output filter and necessary components, pre assembled and wired as required.

Any modifications to a standard product required to meet the specification shall be performed by VFD manufacturer only.

The VFD shall meet the following specific requirements as a minimum.

The fabrication, painting and other such construction requirements of VFD cabinet/panel/enclosure shall meet the requirements as per the specifications for LV panels.

The incoming breaker of VFD feeder shall have micro processor based S/C, O/L and E/F protection (minimum 50kA SC current rating) as minimum along with door interlock facility.

VFD shall be de rated as per manufacturers' recommendation for 50 ^{0}C operating conditions and altitude based on specified site/operating conditions and such de rated current of VFD shall be minimum 110% of full load current of motor as per IS: 12615 (2018)/as per SOQ.

VFD shall be provided with TPN ACB/MCCB and as recommended by VFD manufacturer as per their published chart along with fast acting semi conductor fuse protection, with fuse base and with series contactor. AC3 category (VFD signal to be interlocked with PLC and in manual mode timer based interlock to be provided to ensure that signal to turn on VFD is fed only if contactor close signal is received) to switch off supply to contactor through PLC when soft starter is not ON.

Contractor/Vendor shall furnish the heat dissipation load data and shall provide the cooling arrangement accordingly to ensure that the temperature rise within enclosure does not exceed 5 ^{0}C over the maximum ambient temperature of 50 ^{0}C.

Minimum two cooling fans shall be provided or higher number as required. Cooling fan shall be continuous duty, metal housing with metal impeller, minimum 6" size (minimum 8" for 160kW and above). The enclosure cooling fans and temperature sensing device (RTD/Thermisters) with tripping arrangement shall be provided and shall also be interlocked with VFD operation i.e. in case of cooling fan failure or excess temperature (55 ^{0}C or as set), the VFD shall be tripped/shall not turn on.

Vents for air suction in to panel shall be provided with louvers with filter (front washable and replaceable). However for 160kW rating and above vents shall be Louvers with wire mesh (up to maximum 1mm opening) an in this case enclosure shall be genrally with IP 42 proteciton class.

VFD shall be provided with **conformal coating, to protection level 3C2** for **water supply and sewerage (pumping station/treatment plant) projects** and **protection level 3C3** for **industrial effluent projects** or such harsh environment and according to IEC 60721-3-3.

VFD shall be with programmable keypad with graphical display mounted on door (Remote Mounting) and inbuilt RS 485 serial port for remote communication.

Auxiliary contact of incoming breaker and contactor shall be used in series to provide "VFD Ready" interlock signal for PLC/remote operation.

Input filters, transformer, power conversion, output filters and auxiliary equipment enclosure shall be NEMA 12 design. Air cooled units/enclosure shall be NEMA 12 ventilated, generally IP 52 or better degree of protection, with gasketed doors.

Voltage and Current Harmonics at the supply side of the drive system at PCC (point of common coupling) shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations of the IEEE 519 2014 or latest edition.

VFD manufacturer to provide the harmonic calculations and suggest the required harmonic corrections based on plant SLD at each VFD input and at PCC (Point of Common Coupling) as per the suggested harmonic mitigation plan/solution. Bidder shall provide complete plant SLD with all additional data as required to VFD manufacturer for this purpose.

Performance

VFD shall be capable of producing a variable AC voltage/frequency output to provide continuous operation over the normal 10-100% speed range. As a commissioning and troubleshooting feature, the VFD power circuit shall be capable of operating without motor connected to the VFD output.

VFD shall be capable of producing standard/variable torque for centrifugal pumps and centrifugal blowers and shall produce full rated torque (constant torque) at any speed in the operating range for applications like Positive Displacement type Twin/Tri Lobe air blowers, Screw Pumps etc.

VFD shall be digitally controlled, using Pulse Width Modulation (PWM) with flux vector control open loop and closed loop. It shall have IGBTs in the inverter section throughout the power range.

VFD shall be provided with required EMC filter complying to EN 61800-3 depending on the maximum length of the cable from VFD to motor.

VFD shall be capable of being re-set and operating normally after clearing ground fault.

Harmonics Distortion and Power Factor

The total harmonics distortion of the voltage and current at inverter output shall be as per IEC 61800 and/or IEEE 519-2014/latest edition.

VFD shall include an input filter/reactor/choke to protect itself against damage due to normal transients and surges on incoming power line and reduce harmonic distortion on the AC power line.

VFD system including power factor correction system and/or harmonic filter shall never have a leading power factor under utility or generator operation.
The system design shall not have any inherent output harmonic resonance in the operating speed range.

Motor Compatibility

VFD system shall provide an output waveform that will allow utilization of any standard motors, without any need for any special insulation or de rating.
VFDs utilizing output transformers are not acceptable.

VFD output shall produce no electrically induced pulsating torques to the output shaft of the mechanical system eliminating the possibility of exciting a resonance caused by VFD induced torque pulsations.

VFD shall inherently protect motor from high voltage Delta V/Delta T stress, independent of cable length of motor.
VFD system shall be designed to produce no standing waves or over-voltage conditions based on a cable length. If cable length from VFD to motor exceeds 50meter or is more than recommended maximum permissible length, then output filter shall be provided. If the VFD requires an output filter to meet this requirement, it shall be an integral part of the VFD system or external but as per specification certified by VFD manufacturer.

VFD manufacturer to also recommend the maximum permissible length of cable without an output filter.

VFD system shall be capable of producing full rated torque in the event of a power loss of 5cycles or less and continuous operations with a 30% voltage sag on the input power line.

Serviceability/Maintainability

VFD system should be designed for front access only.

VFD system shall be provided with the capability for remote diagnostics via modem communication /inbuilt communication port RS 485 with PLC/SCADA system at main control room.

VFD shall be suitable for monitor and control from PLC/SCADA.

Protections and Annunciations

Power Component Protection:

VFD system shall include distribution class surge arrestors to protect input transformer and VFD against voltage surges. These shall be integral with the drive panel cabinet.

Protective Features and Circuits (Main Protections):

Over current, short circuit between phase, short circuit between phase and ground, impendent short circuit, input phase loss, output phase loss, motor overload, over voltage, under voltage, over speed, solid state thermal protection, IGBT over temperature, heat sink over temperature, phase reversal etc. and other internal faults.

Upon power-up VFD shall automatically test for valid operation of memory, option module, loss of analogue reference input, loss of communication, dynamic brake failure, DC to DC power supply, control power and the pre charge circuit.

VFD shall have a selectable ride through function that will allow the logic to maintain control for minimum of one second without faulting.

The deceleration mode of VFD shall be programmable for normal and fault conditions. The stop modes shall include freewheel stop, fast stop, DC injection braking and as fast as possible.

Upon loss of the analogue process follower reference signal, VFD shall sense the fault and/or operate at a user defined speed or last speed.

VFD should be able to protect the motor when PTC probes are connected.

VFD shall have interlocking with forced cooling fan operation, where ever forced cooling is provided for the drive motor. VFD shall start only when forced cooling fan is running and VFD shall stop before forced cooling fan stopped/tripped.

VFD should be able to limit the motor terminal voltage to twice the DC bus voltage.

Following minimum controls shall be provided in VFD control panel.

- START
- STOP
- Fault Reset
- Auto and Manual Selection
- Manual Set Points.

The following minimum indications shall be displayed in VFD control panel.

- Ready to Start
- Running
- Motor Running On By-Pass
- Alarms
- Tripped
- Input Voltage and Frequency
- Input Power
- Output Voltage and Frequency
- Output Power and Output Current
- Control Supply ON

- Cooling Failure

Abnormal conditions shall initiate alarm and shut down drive based on the nature of the fault.

VFD shall display all faults in plain text and help screens shall be available to guide the user in the troubleshooting. Codes are not acceptable.

VFD shall be with programmable input terminal/probe for RTD (PT 100) for motor temperature (winding and Bearing) monitoring/control/protection.

Data Displays/Programming Terminal

A door mounted LCD display shall be furnished, capable of displaying the VFD operational status and drive parameters.

The Programming terminal of VFD shall be accessible for programming and control even if the main door is closed.

As minimum the following door mounted digital indications shall be available for viewing through 2/4 line or similar suitable in English language display: Speed Demand in %, Output Current in Amps., Output Frequency in Hz, Input Voltage, Output Voltage, Total 3 Phase kW Output, Kilowatt Hour Meter (Digital Energy Meter) and Elapsed Time Running Meter etc.

Use of shuttle button shall carry out the navigation in the menu and the parameter setting.
Parameter setting shall be easily accessible and user friendly with actual text messages and actual setting range.

The programming terminal shall offer the possibility of memorizing and downloading 4 configurations of VFD to save time during the commissioning and to avoid mistakes.

Preferably 4 programmable function keys shall be available for short cuts, application functions

VFD shall have self diagnostic properties to display faults and warnings as they occur. VFD shall be able to store at least 8 last faults into the fault memory including the value of 11 parameters of monitoring for each fault. The fault memory shall be accessible by the programming terminal.

Design Criteria and Operating Conditions

Rated Input Voltage	:	3 Phase, 380 V to 480 V, +10% / -15%
Rated Input Frequency	:	48 to 63 Hz
Fundamental Power Factor	:	0.97 or better at nominal load
Efficiency	:	≥ 98 % at nominal load
Output Voltage	:	0 - U_N, three phase
Output Frequency Range	:	0 to 500Hz or suitable as per manufacturers' standards
Degree of Protection	:	IP-20/21 as a minimum (stand alone without panel enclosure)
	:	VFD Enclosure/Panel generally with IP 52 protection.
Operating Ambient Temp.	:	Maximum **50 ^{0}C** with continuous current output.
Maximum Operating Altitude	:	1000 m without de-rating
Maximum Relative Humidity	:	95 % without condensation
Mounting	:	Within Enclosure/Panel (Vertical)
Maximum Corrosion Level of the Cooling Air	:	IEC 60721-3-3, class 3C1/as per site condition.
Chemical Gases	:	Coating shall be provided to comply with IEC 60721-3-3 Class 3C3/3C2 as specified above
Solid Particles	:	IEC 60721-3-3, Class 3S2

Maximum Vibration Level	:	According to IEC 60068-2-6
Shock Level	:	According to IEC/EN 60068-2-27
Noise/Sound Level	:	Maximum 80 dB-A at a distance of 3m at any Speed/ Load condition
Harmonic Distortion	:	According to IEEE 519 – 2014 or latest revision
Short Time Overload Capacity	:	110% for 1 minute for Variable Torque Application 150% for 1 minute for Constant Torque Application
Speed Regulation	:	± 5.0 % without encoder or tachometer feedback
Efficiency	:	Minimum 96% at 100% Speed and 100% Load Minimum 95% at 80% Speed and 50% Load
Power Factor	:	Minimum 0.95 True PF lagging from 30% to 100% Speed
Control Supply	:	could be internal so provided by VFD itself, or provided by an external 24V DC supply

Safety

VFD shall integrate the "Power Removal" safety function which prohibits unintended equipment operation. The motor no longer produces torque.

Power removal function shall comply with the definition of the draft product standard IEC/EN 61800-5-2 for both stop functions, Safe Torque Off ("STO") and Safe Stop 1 ("SS1").

This safety function shall comply with standard for safety of machinery EN 954-1, Category 3 standard for functional safety IEC/EN 61508, SIL2 capability (safety control signaling applied to processes and systems).

VFD manufacturer shall provide certified schematics and list of devices in order to comply with IEC/EN 60204-1 stopping category 0 and 1.

The relay contacts shall comply with EN-81 13.2.2.3.

User Interface

VFD offered with possibility to extend/expand the number of inputs/outputs of VFD in future shall be preferred.

Two Analogue Inputs:		
• For Voltage	:	0 to 10V, Programmable
• For Current	:	0 to 20mA Programmable
Potentiometer I/P	:	+ 10V, 10mA maximum
Analogue Output	:	2 x Programmable Analogue Outputs (0 – 20mA) (Programmable for Speed and Current)
Logic Inputs	:	4 x Programmable Logic Inputs, isolated from the mains (One of these inputs could be used for PTC/thermistor probe) All logic inputs may be used either in sink or source
Safety Input	:	One input from above shall be dedicated to the power removal safety function. In option, digital I/P may be used with 115V control supply
Relay Outputs	:	3 x Programmable digital O/P with a changeover dry contact

Following I/Os shall be provided/wired to PLC as a minimum.

Description	**Type of I/O**
Drive On/Off Status	DI
Drive Trip Status	DI

Selector Switch in Auto Mode Status	DI
Drive Start Command	DO
Drive Stop Command	DO
Speed Control Command	AO
% Speed Indication	AI
% Current Indication	AI

Communications

VFD shall have inbuilt communication port to communicate with PLC/SCADA system preferably over MODBUS. Alternately Profibus DP or Ethernet TCP/IP protocol or Device Net or FIPIO or other suitable protocol offered by VFD manufacturer suitable for communication with PLC/SCADA can be accepted subject to provision of same at PLC/SCADA side.

Communication card/protocol and cable as necessitated by PLC/SCADA shall be provided. All drive status monitoring and control shall be possible from PLC/SCADA over communication cable/port.

VFD shall be able to accept/control speed or torque command which may come from different control sources as follows.

- I/O Terminals
- Communication Network
- Programmable Card
- Remote Graphic Display Terminal

Advanced monitoring and diagnostic functions shall be available through the programming terminal like monitoring of following.

- The communication scanner
- Command words sent by the different sources
- Command words taken by the AC drive
- 4 words which addresses are selectable etc.

Application Programming

VFD shall have built-in application macros available in the Simply Start menu, to allow selection of the range of pre-programmed control configurations and further, VFD shall be able to store at least two customer modified macro configuration, to suit the specific application. It shall be possible to reset the parameter settings back to the original macro settings through the key pad. Parameter readouts shall be in the text format and not coded.

Notes:

1. Rest all constructional features and other requirements shall be as per the specifications of LV panel.

2. VFD starter features specified are in general and any manufacturer specific deviations in certain features can be reviewed and accepted based on merit/application requirement.

3. VFD starters meant for application for motors/any other driven equipment of ratings **< 150kW, the VFD starters can be housed in common enclosure of LV PCC/PMCC panels.** The specifications and all other criteria as narrated in details above shall be applicable. However the cubicles for housing VFDs shall be liberally sized to take care of heat dissipation and ensure required degree of protection class. Further such VFD housing cubicles shall be properally and totally segregated from other switchgears/instrument compartments of complete LV panel.

4. The VFD starters meant for application for motors/any other driven equipment of ratings > **150kW, the VFD starters shall have to be provided mandatorily as stand alone panels.**

❖ INDUCTION MOTOR (LOW VOLTAGE)

Scope

This specification covers the design, manufacture, inspection, testing at works, supply, delivery to site, installation, testing at a site and commissioning of TEFC, squirrel cage, solid shaft induction motors with all accessories for driving various pumps/equipment working on three phase LV AC supply required for the complete operation of the plant as per the scope of this work.

All motors shall be as per these specifications unless for any other more stringent requirements mentioned elsewhere.

Codes and Standards

The design, material, construction, manufacture, inspection, testing and performance of induction motors shall comply with all currently applicable status, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also confirm to the IS: 12615 (2018)/IEC 60034 amended up to date.

General Design and Constructional Requirements

Motors shall be continuous maximum rated as per IS: 12615 (2018) and IS: 4722 (latest edition) and preferably be designed for low starting current and smooth acceleration except for cases where the driven equipment characteristic demand otherwise. Motors shall be of 4/6/8 pole design as required and provided with terminal box large enough to accommodate armoured PVC/XLPE insulated Aluminium conductor cable of required/specified size/ratings. Motors shall be of energy efficiency class IE3 as per IS: 12615 (2018) except submersible motors which shall be IE2 as per IS.

All motors shall be foot/flange mounted or as per pump/driven equipment coupling requirements and squirrel cage induction type and shall be capable of developing at least minimum 10% more power than demanded by the Pump/Submersible Pump or driven equipment over its duty point of operation.

The minimum power rating for motors to drive pump/submersible pump/driven equipment should be selected as per table below based on CPHEEO manual to meet the power demanded over its duty point of operation.

Required BKW of Pump/Submersible Pump/Driven Equipment	**Minimum multiplying factor to arrive at motor rating**
Below 7.5 kW	1.3
7.5 kW and above but below 15 kW	1.2
15 kW and above but below 75 kW	1.15
75 kW and above	1.10

Operating Conditions

1) Frequency and Voltage Variation

All LV motors shall be TEFC squirrel cage motor and the motor shall be suitable for the following.

Design Temperature : 50 ^{0}C

Supply Voltage	:	415 Volts, 3 Phase, 50 Hz AC supply
Voltage Variation	:	± 10%
Frequency Variation	:	± 5%
Combined Variation of Voltage and Frequency	:	± 10%

2) Starting

a) Unless otherwise specified, motors shall be designed for direct-on-line starting.
b) Motors shall be designed for re-acceleration under full load after momentary loss of voltage with the residual voltage being 100% and is in phase opposition to the applied voltage.
c) Minimum locked rotor thermal withstand time at rated voltage shall be 10 seconds under cold conditions and 8 seconds under hot conditions. The starting time of motor shall be less than the hot thermal withstand time to permit application of conventional bimetal relays or thermal release against locked rotor and overload conditions.
d) The motors shall be suitable for starting under specified load conditions with 75% of rated voltage at the motor terminals.

3) Direction of Rotation

Motors shall be suitable for either direction of rotation. In case unidirectional fan is provided for motors, direction of rotation for which the motor is designed shall be permanently indicated by means of an arrow. When a motor is provided with bi-directional fans, a double headed arrow should be provided.
Normally clockwise rotation is desired as observed from driving (coupling) end. Ample space shall be provided in terminal box for interchanging any two external leads for obtaining reverse phase sequence.

Perormance

Motors shall be rated for continuous duty S1 unless otherwise specified. For hoist/crane it shall be S4 duty.

All performance characteristics shall be as per IS: 12615 (2018) or latest revision and the torque and other specific requirement shall be selected by the concerned equipment vendor to suit the application.

Construction Details

Motor Casing and Type of Enclosure

Motors for use in safe area shall be of industrial type meeting the specified ambient conditions, starting and operating requirements. Motors for use in hazardous areas shall have type of protection Ex-d or other as per area classification and to meet requirement of applicable Indian Standards.
The motor enclosure including terminal boxes and bearing housing shall have IP 55 degree of protection.

Motor casing shall be provided with a suitable drain for removal of condensed moisture for motors operating in safe area.
All vertical motors shall be provided with suitable canopies covering the motors fully.
Motors designed to handle external thrust from the driven equipment shall be supplied with a thrust bearing at the NDE.
Motors shall have standard frame sizes for various output ratings as per relevant IS.
Motors installed in outdoor areas shall be provided with FRP type canopies/covers of 2mm thick.
All external surfaces of the motor and its canopy shall be given coat of epoxy based paint shade 632 as per IS.

Insulation and bracing

Unless otherwise specified, motors shall be provided with class F insulation with the permissible temperature rise above the specified ambient temperature shall be limited to that of class class B. **VFD operated motor shall be with Class H insulation ONLY with temperature rise limited to Class F.**

The winding shall be tropicalized. The windings shall preferably be vacuum impregnated. Alternately the windings shall be suitably varnished, baked and treated with epoxy gel for operating satisfactorily in humid and corrosive atmosphere.
Windings shall be adequately braced to prevent any relative movement during operation.
Overhung of winding shall be double coated with epoxy gel.

However, motors operating with Variable Frequency Drive shall have winding and other features as follows.

- Winding shall be double insulated, vacuum impregnated.
- Winding shall have class H insulation with temperature rise limited to Class F.
- Motors shall have adequate and suitable cooling arrangement and frame size shall be suitably selected for effective heat dissipation unless otherwise specified in SOQ.
- Motors shall be suitable to continuously operate within 30% to 100% speed range variation.

Phase Connections and Terminal Box

The windings shall be connected in Delta. The ends of the windings shall be brought out into a terminal box.
All motors shall be with six terminals and suitable links to connect them in star or in delta. Motors rated up to and including 2.2kW which may be accepted with three terminals.
The terminal box shall be located on the RHS as viewed from driving (coupling) end (for motors above 3.7kW).
The terminal box shall be rotatable in steps of 90 degree to allow cable entry from any direction.
Adequately sized earth terminal shall be provided in the motor terminal box. Terminal box shall be provided at the side of the motor.

Bearing and Lubrication

Motors shall have grease lubricated ball or roller bearings with minimum L 10 rating life of 5 years (40,000 hours) at rated operating condition.
Bearings shall be capable of grease injection from outside without removal of covers with motors in running condition.
Necessary seal to prevent entry of dust/moisture and loss of grease shall be provided. Grease nipples shall be provided with appropriately located relief devices which ensure passage of grease through the bearings.
VFD operated motor shall be considered with insulated bearings for motor rating 90kW and above (not applicable for package product like turbo blower etc.).

Cooling System

All motors shall be self-ventilated, fan cooled. VFD operated motors shall be VFD duty and shall be fully compliant to VFD drive conditions.

Rotor

The motor shall be squirrel cage type, dynamically balanced to provide a low vibration level and long service life of the bearings.

Shaft Extension

Motors shall be provided with a single shaft extension with key-way and full key. Motor shaft shall be sized to withstand 10 times the rated design torque.

Lifting Hook

All motors weighing more than 30kg shall be provided with lifting hook of adequate capacity.

Earth Terminals

Two earth terminals of adequate size, located preferably on diametrically opposite sides shall be provided for each motor. Necessary nuts and spring washers shall be provided for earth connection.

Accessories

- Anti condensation heaters of 240V, single phase, shall be provided for motors rated 30kW and above. Heaters shall remain ON when the motor is not in service and as such shall not cause damage to the windings. Heaters shall be metal encased with a low surface temperature.
- RTD/BTD: 2 number per phase RTD and 2 numbers BTD for bearings both drive and non driven ends shall be provided for motors rated 90kW and above, suitably terminated in auxiliary terminal box. Separate terminal box shall be considered for space heater and RTD/BTD.
- Name plates shall be provided on each motor as per IEC/IS.
- Noise level and motor vibrations shall be within the limits as laid down in IS.
- **Special application motor for higher pump RPM than motor**: For special applications like high pressure RO pumps etc. where in the pump RPM selected are more than motor RPM, such motors shall be driven by VFD only to achieve higher motor RPM as per pump RPM and the de-rated motor torque at such higher RPM shall be more than pump torque requirement with minimum 10% safety margin or higher as recommended by pump manufacturer/vendor. The motor for such application shall be de-rarted and offered with required higher frame size/rating as recommended by motor manufacturer/vendor and shall be sutiable for VFD duty requiremnts specified.

Notes:

The motor and make of motor as per manufacturers' standards' shall be acceptable for following

- The TEFC squirrel cage induction type drive (motor) for imported equipment coming as part of equipment from foreign country. However same shall be generally meeting IE3 efficiency class requirements.
- DC motors (e.g. Turbo Blowers etc.)
- Motor for special applications viz. Braking applications like mechanical screens, EOT Crane Hoist/Electric Hoist, Electric Actuators, SBR Decanter etc.

Motor Testing

Testing of motors shall comply with the requirements of IS: 4029/IS: 15999.

Motor shall be subjected to all routine tests as per IS: 12615 (2018)/IS: 15999 applicable standard with latest amendments, shall be carried on the motors in OEM factory, in witness of Client/PMC/TPI agency.

All type tests certificates shall be furnished during factory test. Generated values of efficiency and power factors at full load, ½ load and ¾ load shall be furnished by theBidder.

Testing and inspection plan, methodology and applicability for various ratings of motors is specified in details in the Inspection & Testing Chapter provided in this specifications.

Drawings

The contractor shall submit the following documents of motors obtained from motor manufacturer /vendor for review and approval.

- GAD and Preliminary outline dimensional drawings showing details of motor, terminal box etc.
- Typical cross sectional drawing showing constructional details with complete bill of materials and relevant standards.
- QAP, Performance Curves, Marking and labeling plate details.
- Data Sheets/Guaranteed Technical Parameters.

❖ **CABLES**

All power and control cables for use on low/medium/high voltage shall be heavy duty type, multi strand Aluminum/Copper conductor, PVC/XLPE insulated, extruded inner sheathed, armoured and overall PVC sheathed as described below.

The medium voltage power and control cables have following minimum overall cross sectional areas.

a.	Power Cables	:	6 sq mm and above (Aluminium)/Up to 4.0 sq mm (Copper)
b.	Control Cables	:	Up to 2.5 sq mm (Copper)
c.	Lighting Cables	:	Up to 2.5 sq mm (Copper)/6 sq mm and above Aluminium

Cables shall be sized based on maximum continuous load current and permissible voltage drop. The derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other etc. as per applicable standards have be taken into account.

Below ground cables in paved areas shall be in concrete lined trenches with pre-cast concrete covers having proper slope and suitable drainage arrangement to avoid water collection. In unpaved areas cables shall be in cable trenches.

In hazardous areas and transformer bays, trenches shall be completely filled up with sand.
Concrete lined cable trenches shall be sealed against ingress of liquids or gases wherever the trenches are in hazardous area or enter into control room or substation area.

Cable trenches shall be sized depending upon the number and voltage grade of cables to be lined. Where underground cables cross roadways, pipe sleepers at grade etc., they shall be protected by being drawn through PVC sleeves/ducts or suitable RCC Pipes/DWC to provide permanent crossing. Pipes laid shall be sealed at both ends for mechanical protection.

High voltage, medium voltage power, control and signal cables shall be separated from one another/each other by adequate spacing or running through independent pipes, trenches or cable trays as applicable. Cable trays, racks and trenches shall be sized to allow for laying 20% cables in future. Cable installation shall provide minimum cable bending radii as recommended by cable manufacturers'.

Cable route markers shall be installed at every 30meter interval all along the routes of directly buried cable trench and also at locations where the direction of cable trench changes.

All power and control cables shall be of continuous length without intermediate joints. Where joints are unavoidable, these shall be provided with the permission of Engineer-in-charge. All cables shall carry tag numbers for easy identification. In case of control cables all cores shall be identified at both sides by their terminal numbers using PVC ferrules as per interconnection diagrams.

Sequential marking of the length of the cable in meters shall be provided on the outer sheath at every meter. The embossing/engraving shall be legible and indelible.

Control cables having 6 cores and above shall be identified with prominent and indelible Arabic numerals on the outer surface of the insulation. Colour of the numbers shall contrast with the colour of insulation with a spacing of maximum 50mm between two consecutive numbers. Colour coding for cables up to 5 cores shall be as per IS.

A HV XLPE CABLES

Scope

The scope shall cover supplying, laying, testing and commissioning of 3 core cables of circular stranded Aluminium conductors, XLPE extruded dielectric, copper tape screened, armoured, extruded semi conducting compound inner-sheathed and PVC overall sheathed confirming to IS: 7098 Part 2 with latest amendments.
The cables shall be armoured with galvanized steel strip/wire armour.
Cables shall be capable of operating at sustained conductor temperature of 90 ^{0}C and suitable for maximum conductor short circuits temperature of 250 ^{0}C.

Operating Conditions

Electric system

- System Voltage : 11kV
- Frequency : 50Hz

Environment

- Ground Temperature : 35 ^{0}C
- Ambient Air Temperature : 50 ^{0}C
- Atmospheric Conditions : Humid and Dusty

Construction

11kV grade stranded compact circular Aluminium conductor, conductor screen with extruded semi conducting compound, cross linked polyethylene (XLPE) insulated, insulation screening with extruded semi conducting compound in combination with copper tape, GI flat/round wire armoured, PVC outer sheathed HV cable as per IS: 7098 Part 2 with latest amendment.

Cable Marking

Embossing on outer sheath shall be as follows.

The PVC outer sheath shall be legibly embossed/printed with the legend “ELECTRIC CABLE 11000 VOLT”, cable size, IS number, identification of manufacturer and year of manufacture, sequential length marking etc. shall be supplied in non returnable drums as per IS: 10418 standard. Cable identification details as above shall be written on srums also as per IS.

Testing

Manufacturer shall carry out routine tests and acceptance tests in accordance with the relevant IS/IEC standards. Routine/acceptance tests reports shall be furnished before dispatch of cables/supply of cables at site. The copies of Type test results shall be submitted along with each drum length.

B LV Power and Control Cables

The scope shall cover supply, laying, testing and commissioning of low and medium voltage XLPE cables.

All cables shall carry tag numbers for easy identification. In case of control cables all cores shall be identified at both sides by their terminal numbers using PVC ferrules as per interconnection diagrams.

XLPE Insulated Power/Control Cables (Medium Voltage)

1.1kV grade stranded Alluminium/Copper conductor, XLPE insulated, extruded inner sheath, GI strip/ wire armoured (Aluminium armoured for single core cable) LV XLPE cable as per IS: 7098 Part 1 with latest amendment.

RTD/BTD/Signal Cables

Contractor/Vendor is responsible for sizing of all cables considering factors like maximum distance between panel/control room and the units/motors.

Specifications for cables for RTD/BTD/Analog signals shall be as follows.

Cables shall be of 660V/1100V grade, single/multi-pair/triad/core cables as per requirement. Triad/multi core signal cables shall be annealed, tinned, high conductivity 0.5/1.0/1.5 sq mm stranded Copper conductor, polyester tapped PVC insulated number of cores twisted into pair, laid up collectively, individual pair/triad shielded and overall shielded with aluminum mylar tape, armoured with galvanized steel wire/strip, overall sheathed with PVC conforming to IS: 1554 and IEC 189 Part II.

Splicing and Termination

Branch circuit wiring shall be spliced only in switch boxes, panel switch socket outlet boxes light fixtures outlets and circular junction boxes. They shall be made only with approved polycarbonate type connectors. No joints shall be allowed within the conduit pipes, cable entry pipes or ducts for cable laying and wire pulling.

Testing

Cables shall be tested in accordance with IS: 7098.

Finished Cable Tests at Manufacturers' Works

The finished cables shall be tested at manufacturers' works. Following routine tests for each and every length of cable and copy of test results shall be furnished for each length of cable along with supply. If specified, the cables shall be tested in presence of Client/PMC/TPI.

1. **Voltage Test**

Each core of cable shall be tested at room temperature at 3kV AC RMS for duration of 5 minutes.

2. **Conductor Resistance Test**

The DC resistance of each conductor shall be measured at room temperature and the results shall be corrected to 20 ^{0}C to check the compliance with the values specified in IS: 8130 (1976).

Testing and inspection plan, methodology and applicability for various types, sizes and ampere ratings of cables is specified in details in the Inspection & Testing Chapter provided in this specifications.

Cable Test before and after laying of cables at site.

1. Insulation resistance test between phases, phase to neutral and phase to earth.
2. Continuity test of all the phases, neutral and earth continuity conductor.
3. Sheathing continuity test.
4. Earth resistance test of all the phases and neutral.

Sealing and Drumming

Cable shall be supplied in non returnable drums as per IS: 10418 standard. Cable identification details like voltage, size, name etc. shall be written on drums also as per IS.

C Cable Accessories

All accessories like cable glands, lugs and terminal markings etc. shall be used conforming to relevant standards/as specified.
The end termination for HV cables shall be heat shrinkable type.
For 1100V grade cables, Ni-Plated Brass Double Compression type glands weather protection of IP 65 as minimum.
Crimping type lugs of Copper/Aluminium (as applicable) of required sizes shall be used.

D Cable Laying

HV power, MV power and control cables shall be separated from one another/each other by adequate spacing or by running through independent pipes, trenches or cable trays. Cable laying and termination shall be such that chances of cable getting damaged are eliminated.

LV cable shall be laid in cable tunnel / treanch or tray racks. Black shall indicate the neutral, while red, yellow and blue for three different phases. All LV cables when laid on the cable racks shall be properly dressed and clamped as required without criss crossing and unnecessary overlapping. Cables shall be properly dressed and clamped.

Laying of HV and LV underground cables

While routing, necessary barriers and spacing shall be maintained for cables of different voltages in case they are laid side by side (in adjescency).

Telephone/Telecommunication cables shall cross the power cables only at about right angles and these two shall not run in close proximity.

LV cables shall be bent in radius not less than 12 times their individual overall diameters, while HV cable shall have bends not less than 15 times their individual overall diameters.

Cable routing between cable trench and equipment/motors shall preferably be taken through GI/DWC pipe sleeves of adequate size. Pipe sleeves shall be laid at angle of maximum 45 degree to the trench wall. Bending radii of pipes shall not be less than 8 times their individual overall diameters.

It shall be ensured that both ends of the pipe sleeves are sealed with approved WP sealing compound after cabling. In places where it is not possible, cables shall be laid on smaller branch trays.

All cable shall be identified close to their termination point by cable tag numbers as per cable schedule. Cable tags shall be punched on aluminium straps (2mm thick, 20mm wide of sufficient length) securely fastened to the cable and wrapped around it.

Routes of these cables shall be arrived at on the basis of relevant drawings and with due consultation with the Engineer-in-charge.

E Drawings and Schedules

Size of cables shall be given in singe line power diagrams. Cable schedule shall be prepared on the basis of relevant drawings. All cables and wires shall be adequately sized to carry continuously the normal currents expected on the relative circuits. All trenches for electrical cables shall be separate from water or sewage pipe line trenches.

F Splicing and Termination

Straight through joints shall be avoided. In case, these are absolutely necessary they shall be made at convenient locations suitably protected as approved and sanctioned by the Engineer-in-charge but in no case within the conduit pipes or ducts.

Branch circuit wiring shall be spliced only in switch boxes, panel switch socket outlet boxes light fixtures outlets and circular junction boxes. They shall be made only with approved porcelain connectors.

❖ CABLE ACCESSORIES AND MISCELLANEOUS ITMS

This defines specifications and requirements mainly for miscellaneous items and accessories, which are generally supplied by the erection contractor/agency.

All materials, accessories and consumables to be supplied by the contractor shall be selected from the list of specified makes and shall conform to the specifications given here under.

The accessories shall be manufactured in accordance with prevailing latest IS specifications wherever they exist or with the BS or NEC specifications, if no such IS standards are available. In the absence of any specification, the materials shall be as approved by the Client/PMC/TPI.

All similar materials and removable parts shall be uniform and interchangeable with one another. Makes of bought out items selected by the contractor must be from the approved vendor list of tender.

Cable Trays

These shall be channel type, fabricated from structural steel, hot dip galvanised complete with all accessories such as bends, tees and reducers.

MS/Aluminium flat clamps with GI/Chrome plated bolts, nuts/screws to be used for clamping cables.

Sizes of these trays shall be as specified in bill of quantities/drawings approved by Client/PMC/TPI.

Size 150mm and above shall be ladder type and below 150 mm shall be perforated type. Collar size of the ladder type cable tray shall be 100 mm and 50 mm for perforated type.

Alternatively **FRP cable trays** manufactured as per applicable/relevant standards of required thicknesss and sizes are also acceptable with prior approval by the Client/PMC/TPI

Cable Glands

Cable glands shall be heavy duty double compression type of Ni-Plated brass. These shall be suitable for armoured/unarmoured cables, which are being used.

Cable Connectors

Cable connectors, lugs/sockets, shall be of Copper/Aluminium alloy, suitably tinned, solder less, crimping type.

These shall be suitable for the cable being connected and type of function (such as power, control or connection to instruments etc.).

Cable Indicators

All cables shall be identified by cable tag of 2mm thick, 15mm wide of enough length of Aluminium straps securely fastened to the cable. PVC identification number, ferrules shall be used for each wire.

Conduits for Cables

For laying of cables under floor, medium duty GI/UPVC/DWC/RCC pipes shall be used.

Pipe shall be laid at on angle of maximum 45 degree to trench wall. Both ends of pipe shall be sealed with approved water proof sealing compound after cabling work.

Size of pipe shall depend upon the overall outer diameter of cable to be drawn through pipe.

To determine the size of pipe, minimum 40% area of selected pipe shall be free after drawing of cable.

❖ LOCAL PUSH BUTTON STATIONS

Each motor shall be provided with a local control station in the vicinity (area) of the motor.

Construction Features

Push button and related control switches shall be as per IS: 6875.

The local push button station/local control station (LCS) shall have Polycarbonate/FRP/die cast Aluminium enclosure or as specified in BOQ of IP 65 with gland plate with knock out holes suitable for outdoor application.

All control stations shall be suitable for 10A continuous current rating 240V AC as well as 110 V/220 V DC control supply.

All push buttons shall be fitted with 2 NO + 2 NC rated to carry and break 6A at 415V (10A at 240V AC).

The open/close/start push buttons shall be of the momentary contact push to actuate type and shall be green in colour.

The stop push buttons shall be stay put type with mushroom knob and lockable in pressed position and shall be red in colour.

All ammeters shall be of moving iron type having an accuracy class of 1.0 and suitable for 1A CT secondary. The size of ammeter shall be 72mm x 72mm or minimum 65mm dia. The ammeter front glass shall be toughened/transparent Acrylic.

20% spare or minimum 2 number spare terminals shall be considered.

Type of Push Button Stations

Type of LCS	Application	Features Required
Type A	Motor without VFD	Start and Stop PB
Type B	Motor with VFD	Start, Stop, Speed Increment and Speed Decrement. Ammeter if specified in BOQ/Scope of work for motor rated above 30kW
Type C	Motor above 30kW	Start, Stop PB, Ammeter if specified in BOQ/Scope of work
Type D	MOV	Open, Close and Stop PB
Type E	Reversible Motor	Forward, Reverse and Stop PB

- **JUNCTION BOX**

Construction Features

Jnction box shall be with sheet steel enclosure of minimum 2mm thick (14 SWG) and shall be with canopy of 2mm for outdoor application. The enclosures shall be painted with two coats of epoxy paint with final colour shade (both internal and external) of Siemens grey shade RAL 7035 with minimum paint thickness 100 micron.

Separate junction box shall be provided for power and control cable termination.

The boxes shall have Aluminium bus bars supported on insulators suitable for termination of power cables and terminal connectors of required size for termination of control cables.

The bus bar connections shall be suitable for terminations of submersible pump motor flat cable/PVC/XLPE Copper cables and armoured cable from PMCC/MCC as per requirement.

Double compression gland and Aluminium/Copper lugs shall be used for termination.

Minimum 20% or minimum 2 number (whichever is higher) of spare terminals shall be supplied in junction boxes for each size of terminals.

JB shall be wall/stand mounting with zinc passivated bolts and nuts and earth terminals as per IS and name plate as required.

Junction box shall be mounted on required steel structure.

- **INTERNAL AND EXTERNAL ILLUMINATION SYSTEM**

General

The illumination system shall consist of lighting poles, lighting distribution boards, lighting panels/power panels complete with FSU/ELCB/MCB, fixtures, cables, junction boxes, terminal blocks, cable glands, 3 pin 5 A/15 A convenience socket outlets, conduits and accessories and supporting and anchoring materials, lighting fixtures with LED lamps/tubes, sodim vapour lamps, wires etc. All materials, fittings and appliances use in electrical installation shall conform to the relevant IS specifications, required area classification and environmental conditions and shall be anticorrosive painted/FRP enclosures.

The wiring for lighting circuits shall be done by wires run in PVC conduits for indoor areas. For outdoor lighting, wiring shall be done by armoured cables.

Illumination Level

The following minimum levels of illumination (average lux level) shall be provided in the respective areas.

Sr. No.	Area/Building	Illumination Level
1	Pump House/Centrifuge or Press Area/Sheds/Blower Room	150 Lux
2	Control Room/Laboratory	300 Lux
3	Office	200 Lux
4	Switchgear/MCC Rooms	200 Lux
5	Sub Station (Switchyard)	50 Lux
6	Toilet Block/Wash Room etc.	100 Lux
7	Roads/Walkways	10 Lux
8	Yard/Outdoor Area	10 Lux
9	General Process/Outdoor Equipment Area	100 Lux

The lighting fixtures offered shall comply with the following requirements.

a) Luminaries shall have high efficiency Lumen Output/Watts.

b) Enclosures shall preferably be FRP/Cast Aluminium with corrosion resistance paints.

c) All indoor and outdoor lighting fixtures shall be power saving long life LED type only.

All lighting fixtures shall be supplied complete with control gear and lamps. Special fixtures, wherever required to meet operational requirements, aesthetics etc. shall also be provided by the Bidder. Make of lighting fixture shall be embossed on each lighting fixture.

Lighting wiring for indoor applications between LDB to SB shall be done by FRLS PVC insulated, 3/4Core x 4/2.5 sq mm, 660/1100V grade, Copper conductor flexible wire (phase, neutral and earth).

Lighting wiring for indoor applications between SB to lighting fixtures shall be done by FRLS PVC insulated, 3/4Core x 1.5/2.5 sq mm, 660/1100V grade, Copper conductor flexible wire (phase, neutral and earth).

Wiring in the Admin Building, Office, Control room, Laboratory Building shall run through concealed conduit only. While lighting wiring for all plant buildings/structures shall be surface conduit type.

All lighting cables for outdoor application shall be armoured type only.

Conduit wiring shall be done in 25mm dia. minimum 16 gauge black enameled steel structure conduit or PVC concealed conduit with 1100V grade PVC insulated copper wire of minimum size 1.5/2.5 sqmm for fixtures/5A receptacles and 4sq mm for power sockets. Not more than 7 wires shall be accommodated in each conduit. All lighting fittings/convenience outlets shall be earthed through the third wire/separate core in conduit/cable.

All lighting fixtures shall be supplied complete with control gear and lamps. Special fixtures, wherever required to meet operational requirements, aesthetics etc. shall also be provided by the Bidder. Make of lighting fixture shall be embossed on each lighting fixture.

On walkway, platforms and other outdoor areas, lighting fixtures shall be nearer to landing of stairs or ladders, gauges, flow meters, panel boards or other equipment requiring good illumination.

In outdoor equipment area at ground level, lighting fixtures shall be mounted preferably 4 meter above floor level. Where this is impractical, the minimum height of any lighting fixture shall not be less than 2.5meter. Socket outlets in process plant areas shall be approximately 1200mm above floor level and 300mm above floor level in office area.

Lighting/power panels shall be mounted such that the top of the panel ie 1800mm above finished grade. Control gears of lighting fixtures with separate control gear shall be mounted at suitable height from ground/platform for easy access/maintenance.

All lighting circuits and convenience receptacles shall be fed from lighting/power panels. Main/Lighting Distribution Board (MDB/LDB) shall be dust and vermin proof and shall be provided with SFUs (HRC)/MCCB as incomer and outgoing feeders where fault level is more than 9kA.

Main and Branch Distribution Boards

Each main DB should be provided with 4 pole isolator as incomer and DP ELCB+MCB as outgoing circuit in each phase and all sub DBs should be with Isolator + ELCB as in comer and MCB as outgoing to control and for protection of lighting circuits.
All DBs should be double door type. Hinged door to cover the operations knobs shall be provided. MCBs shall not be loaded beyond 80% of rated capacity. Minimum of 20% MCB in each panel shall be kept as spare. Power and lighting panel shall be of 16 gauge sheet steel construction and shall be suitable for surface or flush mounting.

All outdoor lighting shall be automatically controlled by means of synchronous timers with manual override control. Normally about 8-10 fixtures shall be wired in each circuit. Lighting feeders requiring automatic control shall be provided with contactors of suitable rating.

Sufficient number of three pin type 5A/15A receptacles as per IS: 1293 shall be provided. Flush mounting type receptacle shall be used where concealed wiring has been adopted and surface type shall be used for other areas. For exhaust fans and wall mounted air cirucaltors, socket and switch enclosure shall be separate whereas for rest receptacle and controlling on/off switch shall be mounted in the same enclosure.

In building such as sub station, DG shed, workshop, maintenance shop etc. industrial type metal clad socket outlets and plugs shall be provided. The sockets shall be supplied complete with plugs.

Adequate number of ceiling fans of 1200mm sweep (with double ball bearing and regulator) shall be provided in offices and rooms allocated to operating and maintenance personnel etc. In places where ceiling fans are provided, lighting fixtures shall be suspended below fan level with the help of conduits/chains to avoid shadows on the floor.

Minimum 2 number or sufficient exhaust fans as required during detailed engineering/ recommended by equipment manufacturer shall be provided at battery room, laboratory room, sub station/switchgear-MCC room, DG room, all pump houses, filter house etc.

The exhaust fans shall be provided with louvers/net to prevent insects. For pump house below ground level, suitable GI ducts for exhaust shall be provided as decided during detailed engineering and instructed by Engineer-in-charge.

Lux levels shall be maintained at various locations as indicated above and shall be backed up by calculations from manufacturer.

Switch Box

Switch Box shall be made of metal on all sides, except on the front.

In the case of cast boxes, wall thickness shall be at least 3mm and in case of welded mild steel sheet boxes the wall thickness shall not be less than 18 gauge for boxes, up to a size of 20cm x 30cm and above this MS boxes having minimum sheet thickness of 1.6mm shall be used. Switch boxes shall be galvanized after fabrication. Except where otherwise stated 3mm thick phenolic laminaged sheets like summica shall be fixed on the front with brass screws. Clear depth of the box shall not be less than 60mm and this shall be increased suitably to accommodate mounting of fan regulators inflush pattern. All fittings shall be flush pattern. It shall be provided with adequate number of knock outs on all sides for ease of wiring either with conduits or without conduits.

Modular type switch boxes are also acceptable.

Wiring/Conduit System

Surface Conduit Wiring System

PVC conduits pipes of approved minimum 1.6mm wall thickness shall be used. The minimum PVC conduit diameter shall not be less than 25mm. Maximum number of wires permissible in a conduit shall be seven/nine for wire size of 2.5sq mm/1.5sq mm respectively.

In long distance straight run of conduit, inspection type junction box at reasonable intervals shall be provided.

Fixing of Conduit

Conduit pipes shall be fixed by heavy duty GI pressure saddle with screws in an approved manner at an interval of nore more than one metre but on either side of the couplers bends, or similar fittings, saddles shall be fixed at a distance of 30cm from the centre of such fittings. The saddle should not be less than 20 gauge for conduits.

Where conduit pipes are to be laid along the trusses, steel joints etc. the same shall be secured by means of ordinary clips or girder lips as required by the Engineer-in-charge. Where it is not possible to drill holes in the truss members, suitable clamps with bolts and nuts shall be used. The width and the thickness of the ordinary clips or girders clips and clamps shall not be less than as stated below.

Recessed Conduit Wiring System

Recessed PVC conduit wiring system shall comply with all the requirements of surface conduit wiring system specified in clauses above and in addition to the requirements specified in the following clauses.

The chase in the wall shall be neatly made and of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, fixed work, specials care shall be taken to fix the conduit and accessories in position along within the building work, to avoid damage to the finished wall etc.

All outlets such as switches, wall sockets etc. shall be flush type.

The outlet box shall be same as above and shall be mounted flush with the wall. The metal box shall be efficiently earthed with conduit by an approved means of each attachment.

To facilitate drawings of wire in the conduit. GI mesh wire of 10 SWG shall be provided while laying of recessed conduit.

Lighting Poles

Steel Tubular Swaged Type

Street light poles shall be steel tubular swaged type made from GI pipe conforming to IS: 1239 medium class and made as per IS: 2713.

Street light pole, steel tubular swaged type, 9/7.5/6 meter long (6/4.5/3.0m x 1.5m x 1.5m) 139.7mm, 114.3mm, 88.9mm dia. respectively and 4.85mm, 3.65mm, 3.25mm thick respectively, with MS base plate.

Steel Octagonal Type

Steel octagonal pole with base plate made from CR sheet steel. The pole should be made as per IS and shall be coated with hot dip galvanizing as per IS: 2629/4759 with required base plate and suitable to sustain local wind speed.

Lighting poles shall be of octagonal poles made from sheet steel confirming to BSEN 10025. Internal and external surface of octagonal pole shall be hot dip galvanized to minimum 65 micron DFT. Octagonal poles shall be provided with base plate and provision for fixing foundation bolts. Base plate shall be as per IS: 2062. All poles are tapered octagonal and shall be in single section.

The street light poles shall have minimum 6meter height, Top dia. – 70mm, Bottom dia. – 130mm and 3mm thickness sheet with bracket for mounting the light fittings and all required accessories. Base plate of minimum dimension 200mm x 200mm x 12mm.

The Flood light poles shall have minimum 9meter height, Top dia. – 70mm, Bottom dia. – 155mm and 3mm thickness sheet with bracket for mounting the light fittings and all required accessories. Base plate of minimum dimension 260mm x 260mm x 16mm.

All poles shall be supplied along with pipe cap, single/double arm of 1m/0.5m height and over hung 1m/1.5m long GI pipe having dia. to suit the socket of 250/150/70W etc. 240V, HPSV/LED/MH/HPMV lighting fixture as applicable and with following.

1. PVC junction boxes on pole with 8 way connector and 1 no. 4A SP MCB.
2. Street light pole shall be as per approved drawings.
3. Internal pole wiring with 3 core 1.5/2.5sq mm flexible stranded copper conductor, FRLS insulated wire from junction box to up to Street light/Flood light/fixture as required.

Balancing of Circuits

The balancing of circuits in three phase installations shall be arranged before hand to the satisfaction of Engineer in charge.

Drawings

All wiring diagrams shall indicate clearly in plan, the main switch board, the distribution fuse board, the run of various mains and sub mains and the position of all points with their classification.

Rating of Lamp, Fans, Socket Outlet Points and Exhaust Fans

Lamps installed in pump house and other means shall be LED Type only.

Table fans and ceiling fans shall be rated at 60watts. Exhaust fans shall be rated according to their capacity.

5A socket outlet points and 15A socket outlet points shall be rated at 100watts and 1000watts respectively, unless the actual values of load are known or specified.

Capacity of Circuits

Lights and fans may be wired on a common circuits, such circuit shall not have more than a total of ten points of light, fan and socket outlet or a load or 800watts whichever is less.

Power circuits on buildings shall be designed with a maximum of two outlets per circuit, based on the loading.

Where, not specified the load shall be taken as 1kW per outlet. Wherever the load to be fed is more than 1kW it shall be controlled by an isolator switch or miniature circuit breaker.

Indoor and Outdoor Light Fixtures/Lightings (LED LIGHTING)

LED fixtures shall be generally having following.

- LED luminous Efficacy lumens/watt : 100% minimum
- Efficiency of Electronics System : 80% - 85% minimum
- LED Lamp/Light Efficiency : 85% - 90% minimum
- Total Harmonic Distortion : For Outdoor Fittings: ≤ 20%
  For Indoor Fittings: ≤ 20%
- Power Factor : ≥ 0.85
- Colour Rendering Index (CRI) : ≥ 70
- Colour Temperature/Apparent : ≥ 5700K (Cool day light)
- Radiation : No Ultra-Violet (UV) or Infra-Red (IR) No RF to interfere with radio equipment
- LED Life : Long Life, generally 50,000 Hrs.
- RoHS compliant, Eco Friendly green technology, Mercury free.
- Outdoor LED fixtures must be fully enclosed with minimum IP Rating of IP 66/65 (Weatherproof). LED optical system must be gasketed (enclosed) to minimize light dirt depreciation.
- Electrical safety for outdoor LED Lights shall be of class I.
- Luminaries must be clearly marked with manufacturer name, model number, electrical rating and agency approval (If applicable - CSA, UL etc.).

Industrial Luminaire

Indoor LED wall mounting Industrial Luminaire shall be LED type minimum 10W to 48W.

Each fitting shall be required LM 79 and LM 80 Certificates.

Tube light shall be 20W or higher wattage with integral/non integral driver, surge 4kV, IP 20, 4 feet with LEDs of wattage 0.2W to 0.5W assembled on single MCPCB with housing used as a heat sink shall be made of thick sheet steel conforming to IS: 513/CRCA polyester powder coated and high UV and corrosion resistance with diffuser and/or Polycarbonate optics with company mark/name.

120 to 300V, Power Factor more than 0.9, THD < 20%

CCT 4000 K to 6500K, Uniformity Ratio > 0.7,

Luminaire Efficacy > 85 lumens/watt ,

LED Driver Efficiency > 85 %

Fixtures shall be with earthing arrangement facility suitable for ceiling or pendant mounting suitable for 19mm conduit with stove enameled reflector gray outside and white inside which can be installed without aid of any tools, complete in all respects and ready for use.

Emergency Light

Emergency light unit working on 230V AC supply shall be self containing LED type of minimum with 20W & 600mm long type 'SWITCH ON MAIN FAILTURE. It shall be electronic automatic type which incorporates a unit trickle charge circuit, which shall prevent over charging or battery The battery shall be maintenance free. The unit shall provide 4 hours illumination following power failure. The units shall generally conform to IS: 9583.

Gate Lights

The gate lights shall be post top lantern LED type, weather proof and shall be suitable for use with one number 40W LED and asthetics appearance shall be as approved by Client/PMC/TPI.

Post Top Lantern LED fitting comprises of Copper dust finish die cast aluminum spigot and spun aluminum canopy fixed with opal polycarbonate, pipe arrangement for vertical mounting,open construction driver and accessories wired upto terminal block.

The post top lantern shall be suitable for use with one number 40W LED.

GI pipes of suitable dia. shall be provided at gate concrete pillar as conduit for wiring and fixing post top lantern luminaire.

Outdoor Yard/Road Lighting

Outdoor Luminaire

The luminaire shall be LED type with minimum 40W to 240W LED complete with all accessories and each street light/flood light industrial luminaire shall be IP 65 and Surge 4kV and shall be required LM 79 and LM 80 certificates.

LED outdoor street light/flood light/well glass industrial luminaire shall be with high power white LEDs wattage of 1watt and above assembled on single MCPCB, efficiency more than 130 lm/w and corrosion free high pressure die cast aluminum housing with smooth finish powder coated and heat sink extruded aluminium with diffuser and Polycarbonate optics/lenses with company mark/name engraved or embossed.

120 to 300V,
Power Factor more than 0.95,
THD < 20%,
CCT 5000 K to 5700 K,
Uniformity Ratio > 0.45,
Luminaire Efficacy > 85 lumens/watt,
LED Driver Efficiency > 85 %.

The required parameters of LED fixtures have been enumerated above.

- **EARTHING SYSTEM**

Earthing system design and installation shall generally be as per IS: 3043. All metallic non current carrying parts of electrical apparatus, current and potential transformer secondaries, columns, vessels, towers,

stacks, storage tanks etc. shall be earthed at least by two distinct separate earth conductors from the earth plate connected to main earthing loop.

The main grid conductor shall be hot dip galvanized MS flat. The amount of galvanizing shall be minimum 610 gm per sqm. The main earth loop shall be laid at a depth of 500mm below grade level.

Earthing conductor shall be laid around the battery limit of the plant. Horizontal conductors shall be laid in both longitudinal and transverse direction to facilitate earthing of various equipment in most economical and reliable manner.

Cable trays in process areas shall be earthed with the help of risers emerging from main earthing conductors laid below/adjacent to structures carrying cable trays. Trays shall be earthed at an interval of approximately 30meter and in any case shall be connected to the earthing grid at minimum two points.

Joints and tappings in the main loop shall be made in such a way that reliable and good electrical connections are permanently ensured. All joints below grade shall be welded and suitably protected by giving two coats of bitumen and covered with hessian tape.

Adequate number of minimum 65mm dia. or higher size as per IS: 3043, 3meter long GI pipe earth electrodes with earth pit shall be provided. All earth electrodes shall preferably be driven to a sufficient depth to reach permanently moist soil.

Multiple earth connection shall be taken from suitably located earth plates connected to earth loop. All hardware used for earthing installation shall be hot dip galvanized or zinc passivated. Spring washers shall be used for all earthing connections of equipment. Unless otherwise specified, earthing connections to individual equipment shall be done in accordance with standard equipment earthing schedule.

Lightening protection shall be provided for equipment, structures and buildings as per IS/IEC 62305. Self conducting structures may not be provided with aerial rod and down conductors but shall be connected to the earthing grid at minimum two points of the base. An independent earthing network shall be provided for lightening protection and this shall be bonded with the main earthing network minimum at two points at the buried electrodes.

The resistance value of an earthing system to the general mass of earth for the electrical system and equipment shall be as follows.

a) For the electrical system and equipment a value that ensure the operation of the protective device in the electrical circuit but not in excess of 5ohms. However, for generating stations and sub stations this value shall not be more than 1ohm.

b) For lightening protection, the value of 5ohms as earth resistance shall be desirable, but in no case it shall be more than 10ohms.

Connection

The earth system connection shall generally cover the following.

Equipment earthing for personnel safety
System neutral earthing
Static and lightning protection
System neutral
Current and potential transformer secondary neutral
Metallic non current carrying parts of all electrical apparatus such as transformers, switchboards, bus ducts, motors, neutral earthing resistors, capacitors, UPS, battery charger panels, welding receptacles, power sockets, lighting/power panels, control stations, lighting fixtures etc.

Steel structures/columns etc.
Cable trays and racks, lighting mast and poles
Storage tanks, vessels, and all other process equipment
Fence and Gate for electrical apparatus (e.g. transformer, yard etc.)
Cable shields and armour
Shield wire

All main earthing shall be used for earthing of equipment to protect against static electricity.

All LV, medium and high voltage (HV) equipment (above 250V) shall be earthed by two separate and distinct connections with earth.

Plant instrument system clean earthing, UPS system clean/safety earth shall be separate from the electrical earthing system.

All earthing connections for equipment earthing shall preferably from the earth plate mounted above ground wherever provided. Equipment foundation bolts shall not be used for earthing.

Earth connections shall be made through compression type cable lugs/by welded lugs.

All hardware used for earthing installation shall be hot dip galvanized or zinc passivated. Spring washers shall be used for all earthing connections and all connections adequately locked against loosening.

Lighting fixtures and receptacles shall be earthed through the extra core provided in the lighting circuit/cable for this purpose.

The reinforcements of sub station building and sub-station floor shall be connected to main earth grid.

The earth electrodes shall be situated at a distance not less than 3meter from the building fencing structure and equipment foundations. The surrounding the electrodes, soil shall be treated up with salt, coke and charcoal. The distance between two electrodes shall not be less than twice the depth of electrode.

Minimum requirement of earth pits as per IE rules are as under.

- Two numbers independent for transformer body.
- Two numbers independent for transformer neutral.
- Two numbers independent for two/four pole structure.
- One number for lightning arrestors.
- Two numbers for LV panel at sub station and at pump house.

The main earth electrodes after being driven into the ground shall be protected at the top by constructing concrete or block masonry chamber or pre-cast chambers of size 300mm x 300mm x height 300mm with CI cover. The resistance of any point in the earth continuity system of the installation to the main earth electrode shall preferably not exceed 1ohm. The remaining space in the bore hole shall be filled with bentonite. The bentonite will hold the earth road in position. The neutral conductor shall be insulated throughout and shall not be connected at any point to the consumers earthing system.

It shall not be allowed to use the armour of the incoming feeders cable to the sub-distribution board as the only earthing system.

Sheathed lugs of ample capacities and size shall be used for all underground conductors for sizes above 3 mm^2 whenever they are to be fitted on equipment of flat copper conductor.

The lugs shall be fitted on equipment body to be grounded or flat copper only after the portion on which it is to be fixed is scrubbed, cleaned or paint or any oily substance on a subsequently tinned.

No strands shall be allowed to be cut in case of stranded ground round conductors. GI embedded conduits shall be made electrically continuous by means of good continuity fixing and also rounding copper wires and approved copper clams.

Earthing of Lighting Poles

All external poles are to be looped together with continuous 8 SWG GI earth wire clamped a dollies provided on every fuse box of poles and looped onwards to the other pole. Every fifth pole shall be connected to earth through an earth electrode.

Recommended Size of Earthing Conductors

Below mentioned are the recommended minimum sizes of earth conductors. However, Earthing strips/conductors, if required of higher size as per Ground Fault Calculations, should be laid as per SOQ or as per site requirement.

Type of Equipment	**Earth Conductor (See Note)**
Motors upto 3.7kW	8 SWG solid GI wire
Motors from 5.5kW to 30kW and welding receptacles	10mm dia GI wire rope
Motors above 37kW	16mm dia GI wire rope OR 40mm x 5mm GI strip
Building columns, fencing	40mm x 5mm GI strip
Storage Tanks (Vertical/Horizontal)/Vessels	40mm x 5mm GI strip
Small equipment and instrument	8 SWG GI solid wire
Lighting, Power and Instrument Panels	10mm dia GI wire rope
Main Earth Bus/LV and HV Switchgear Interconnections	75mm x 8mm GI strip
Power Transformer/HV Sub stations	50mm x 6mm Cu for Neutral 75mm x 8mm GI strip for rest
Push Button Stations (LCS)	8 SWG GI solid wire
Street Light Poles	8 SWG GI solid wire
Lighting Transformer	16mm dia. GI rope
Pipe Rack	40mm x 5mm GI strip
Bonding of pipe	25sq mm insulated flexible Cu cable

Notes:

1) Earth connection to individual equipment from nearest earth plate/grid may also be done alternately using aluminium/copper conductor PVC insulated core of size note less than half the cross section of the respective power cable to equipment (motor, panel etc.). Connections shall be made using crimpt type lugs.
2) Number of runs of Cu/GI earthing strips shall be as per ground fault calculations.
3) The size of strip mentioned may be changed as per availability meeting the minimum area requirement of specified size of strip/conductor.

Maintenance Free Safe (Chemical Type) Earthing System

Chemical type earthing electrode shall be used for equipment body earthing. It shall be made with steel core and a copper exterior to provide increased conductivity and corrosion resistance. The electrodes shall be minimum 3meter length, 17mm diameter with 99.9% pure electrolyte copper coating of minimum 250 microns and ANSI/UL 467 approved. Adherence of copper to steel rod is achieved through a pioneered bright acid copper plating process using 14 stations using proper current densities, temperature and brightener additives to achieve copper plating with finer grain structure and a smoother, harder and more

uniform surface. It shall have minimum tensile strength of 80,000 PSI and straightness tolerance 0.01" per linear foot and shall meet the requirement of ANSI/UL 467, CSA and ANSI/ NEMA. UL logo and control number where applicable shall be stamped on each rod for easy inspection after installation. The rod shall be tested according to IEC 62561-2 and comply to the requirements of IEC 60364-5-54.The rods also should withstand short circuit currents. All fasteners used should confirm to the requirements of the above standards.

Back filling compound used shall have resistivity less than 20ohm-cm in its set form. Earth resistance shall be remained same over a wide temperature variation of -60 ^{0}C to + 60 ^{0}C. It shall be suitable to absorbs and retains moisture for long time and shall reduced soil resistivity, Dissipate fault current very fast, Eliminate needs of salt and chemical around electrode and maintain compatibility of soil and rod contact. Earth enhancing compound (Soil conductivity improver) used should be tested according to IEC 62561 – 7 from an NABL accredited laboratory. Exothermic welding material used shall be tested as per IEEE 837

Construction Procedure of Chemical Type Earth Pit

A hole of 100 to 125mm dia. shall be augured/dug to a depth of about more than 3meters or as per instruction of Engineer-in-charge.
Earth electrode of minimum 3meter length shall be placed into this hole.
It will be penetrated into the soil by gently driving on the top of the rod. Here natural soil is assumed to be available at the bottom of the electrode so that min 150mm of the electrode shall be inserted in the natural soil.

Earth Enhancing material (minimum 20kg) shall be filled in to the augured/dug hole in slurry form and allowed to set. After the material gets set, the diameter of the composite structure (earth electrode + Earth Enhancing material) shall be of minimum 100mm dia. covering entire length of the hole.
Remaining portion of the hole is filled with backfill soil which is taken out during auguring/ digging.
Construction of masonry earth chamber and cast iron cover with earth resistance result with date or as per instruction of Engineer-in-charge.
For interconnection to the main earthing grid, 40mm X 5mm thick copper clamp shall be provided.

A) PIPE-IN-PIPE Technology Safe earthing

Two pipes of coaxial diameters joined together for enhancing the service life and performance of the overall earthing system.
The cavity in between the electrodes shall be filled with crystalline conductive compounds for current dissipation and anti corrosive properties.
The electrode cross section shall be circular for the uniform distribution of fault current all around from electrode to earth.
Inner pipe of length 3meter shall be hot dip galvanized/zinc coated with minimum galvanizing thickness 80 - 100 micron or Copper plated (minimum 250mm) as per Drawing/SOQ. Minimum size of pipe as per Drawing/SOQ.
Outer pipe of length 3meter shall be hot dip galvanized/zinc coated (minimum 150 micron) or Copper plated (minimum 250mm) as per Drawing/SOQ. Minimum Size of pipe as per Drawing/SOQ.
A hole of 200mm - 225mm dia. shall be augured/dug to depth of about more than 3meters or as per instruction of Engineer-in-charge.

Earth enhancing compound of minimum 50kg shall be filled. **Earth enhancing compound shall be filled till top of Earthing Pipe electrode.**

B) Plate Type Earthing Stations

The earthing station shall be as per drawing/IS: 3043. The equipment neutral earthing shall be with Copper plate earthing station.

The plate electrode shall be 600mm x 600mm x 3.15mm Copper plate for neutral earthing.
The earthing conductors shall be of Copper strip in plate type earthing.
GI pipe with funnel of good quality shall be used for watering the earthing electrodes/stations.
The brick masonry or pre case CC chamber with cover/chequered plate shall be provided for housing the above referred funnel and pipe.

Earthing Unit Measurement

Earthing station/pit complete with excavation, electrode, watering pipe, soil treatment, masonry chamber with cast iron cover etc. as per tender specifications/drawings shall be treated as one unit.

Different sizes of strips/wires per unit length covering/including cost of interconnection the earthing station to earthing grid, and to respective equipment with fixing accessories like earthing clamps, saddle, labour etc. shall be traded as unit length.

The earth system connection shall generally cover the following.

1. Equipment earthing for personnel safety
2. Transformer, DG and System neutral earthing
3. Static and lightning protection
4. Current and potential transformer secondary neutral
5. Metallic non current carrying parts of all electrical apparatus such as transformers, switchboards, bus ducts, motors, neutral earthing resistors, capacitors, UPS, battery charger panels, welding receptacles, power sockets, lighting/power panels, control stations, lighting fixtures ceiling fan and exhaust fan, street light, flood light pole circuit/cable.
6. Fence and Gate for electrical apparatus (e.g. transformer, yard etc.)
7. Cable shields armour and shield wire.

The scope of work shall also cover supply, laying, installation, connecting, testing and commissioning of following.

- Plate (600mm x 600mm x 3.15mm Copper plate) type/Pipe type (Chemical type) earthing station with Copper bonded earth electrode/Copper plate of size as per tender/IS.

- Earthing Copper strips from Plate earthing station and hot dipped GI strip for pipe earth to equipotential bar/earth grid.

- Earthing GI/Copper strips/wires from earth grid/equipotential bar to power panels, DBs, motors, indoor/outdoor lighting systems etc.

- Bonding of non current carrying parts and metallic parts of the electrical installation.

- Quantity of pits mentioned are minimum or higher as per soil resistivity. Measurement of soil resistivity to be carried out by contractor at no extra cost.

- All the earthing material and installation and construction of earth pit, chamber etc. shall be as per IS: 3043 and tender.

- Galvanising thickness shall be 86 micron and 610 g/m^2 as a minimum.

❖ SAFETY EQUIPMENT

The contractor shall provide safety equipment and accessories for HV panels, DG panels, LV control panels etc. as per statutory requirement.

Generally following shall be provided as a minimum (forming part of scope of this work).

- Supply and spreading synthetic rubber mat, 1meter wide, 2mm thick, conforming to IS: 15652 Class A for 1.1kV LV voltage in front of LV PMCC/MCC/LVDB/APFC etc.
- Supply and spreading 1meter wide 2.5mm thick synthetic insulating mat as per IS: 15652 Class B suitable for operation of 11kV equipment in front of all HV panels for their entire length. The insulating mat should have ISI mark on every one meter.
- Pairs of electrically tested 22kV rubber gloves. These are to be kept in a suitable wooden box.
- A shock treatment instruction chart in English and local language duly framed as detailed in IS: 1355. Details of the nearest medical facility available with phone number shall also be kept.
- First aid box containing first aid kit for treatment of electrical burns in the main switch room.
- ABC powder type 'Ceasefire' portable type Fire Extinguishers as per IS: 13849 of minimum 4.5 Kg capacity with necessary clamps for erection on wall for individual substation, HV and LV panel/control rooms as required and as per fire safety guidelines and norms.
- Danger/Caution notices in English shall be fixed permanently on the equipment, LV, HV panel room, switch yard etc to comply the requirement of IE rules.
- Safety posters for vigilance against electrical accidents as detailed in IS: 1255.
- Fire buckets with MS angle stand and with 4 number round bottom fire buckets marked fire shall be provided in the LV panel room, HV sub station and at transformer yard. Stand shall be with canopy. Stand shall be grouted in RCC.
- 3meter and 6meter long folding Aluminium ladders for safe maintenance of lighting system etc.
- SLD and earthing layout of suitable size duly framed/laminated shall be fixed on the wall near the entrance.
- Any other as per statutory norms / requirement shall also be provided.

❖ DIESEL GENERATOR SET (ALONG WITH AMF PANEL/AMF CUM SYNCHRONISING PANEL AS APPLICABLE)

Supply, installation, testing and commissioning of Diesel Generating set of KVA rating as per SOQ at 0.8 PF, 1500 RPM (4 Pole), 415 V ± 2.5%/1% and 50 ± 1% Hz or more, 3 phase, 4 wire complete with control panel, controller, cabling etc. as applicable and necessary controls and safety devices in panel confirming to relevant IS specifications. The set must be of continuous operational duty with speed regulation of ± 1% or better. Diesel engine shall be conforming to relevant ISS/BSS/ISO with latest amendments and as per latest CPCB norms.

DG set rating shall be for prime rating power (PRP) in accordance with BS 5514/IS/ISO 3046. DG set engine shall be as per CPCB II/Present prevailing and applicable norms. DG set shall comply with latest emission norms of Ministry of Environment and Forest (MOEF) by Government of India.

DG set shall meet all latest statutory/pollution control regulation requirement and applicable safety codes. It must fulfil all norms, provisions and conditions set by concerned and relevant Statutory Authorities.

Foundation shall be as per OEM recommendation.

Generating Set

The DG set shall be Prime Duty, comprising diesel engine of adequate capacity directly coupled to an alternator mounted on a common rigid steel base frame.

The rated capacity shall be as per SOQ/tender specifications.

DG set is required to function at places situated at an altitude up to 1000 M, ambient (cooling system) temperature up to 50 ^{0}C and relative humidity up to 95%.

DG set should be able to start by push button starting.

The entire DG set shall be with 2 year comprehensive warranty and extended warranty of 3 years from thereon by manufacturer on complete DG set as specified in warranty clause indicated elsewhere.

The controller of DG panel shall be with RS 485 port (Modbus protocol) for remote data monitoring and logging.
COP (confirmation of product) of Nodal/Statutory authority shall be provided by manufacturer for noise and emission levels.

It shall comply with noise level and emission levels as per latest revised norms of MOEF, GOI.

It shall be with suitable accoustic enclosure to meet MoEF/CPCB norms. Enclosure shall be made of CRCA sheet and high quality noise absorbent and fire retardant grade acoustic insulation material to IS: 8183.

A. Engine

Diesel engine shall have constant speed, water cooled, suitable for generating set application 1500 RPM, powered by multi cylinder, turbo charged after cooled, cold starting, heavy duty type rated in accordance with ISO 3046/IS with latest amendments

Engine cooling system shall be designed and tested to 50^{0}C ambient temperature.

Engine should be preferably from the engine manufacturers who maintain quality assurance to international standard of ISO 9001.

The noise level should not be more than 75 dB at 1 meter distance and engine exhaust smoke emission level shall comply latest revised emission norms of MOEF, GOI.

Diesel Engine below 140kVA rating shall have mechanical governing system and 140kVA and above rating shall be with Electronic governing system.

The engine should have automatic belt tensioning arrangement for battery charging alternator system.

The engine should have facility for the indication of oil level in oil sump during running of the engine.

The engine water circular pump should be directly driven by engine gear system. V belt driven system will not be adopted/accepted.

The engine shall be rated for continuous duty at site ambient conditions with an inherent overload capacity of 10% for 01 hour in any 12 hours.

The engine should have equipped with the following accessories.

- Fly wheel to suit flexible coupling with guard
- Dry type air cleaner
- Corrosion inhibitor liquid
- Fan blower type with guard
- Radiator with guard
- Water pump, centrifugal type, engine mounted
- Fuel pump PT type, Fuel filter
- Governor – Electronic type to meet test requirements as per ISO 8528
- Fuel injection equipment
- Exhaust Silencer, Hospital Grade type with spark arrestor. Height of exhaust pipe above DG room height shall be as per pollution control regulation and supported with MS angle iron supports and stay wires. The exhaust pipe to be wrapped with asbestos rope till the end point.
- Electric starting equipment comprising starting motor with soft start engagement feature on 12/24 V DC supply
- Lub oil cooler, Lub oil pump, Lub oil filter
- Turbo charger
- Solid state potentiometer for increase or decrease of speed which can be wired with remote operation. (For DG with synchronizing only, not applicable for solo application)
- Any other as required

B. Power Control Unit

Micro processor based power control unit for monitoring, metering, protection and control system with LED backlit LCD display. DG set shall have Modbus interface.

Engine Metering	**Alternator Metering**	**Engine Protection**	**Alternator Protection**	**Operator Interface**	**Data logging**
Speed of Engine in RPM	3 Phase voltage (phase to phase and phase to neutral)	Low lube oil pressure	Over/under Voltage	Manual stop/start	Engine hours
Lube oil pressure	3 Phase current	High/Low coolant temperature	Over current, short circuit	Remote start/stop	Engine starts
Coolant temperature	Frequency	Over/under DC voltage	Over/under frequency	---	Up to 10 recent fault records
Battery Voltage	kVA	Fail to Crank/ start	Loss of AC sensing		
Running hours		Weak Battery	Field overload	---	
---	---	Over-speed		---	
		Sensor failure			

C. Alternator

Alternator shall be rated for 40 ^{0}C design ambient temperature, altitude up to 1000 M, relative humidity 95%. It shall be based on **80% loading** (unless otherwise specified in SOQ) and 0.8 PF. Short time overloading of alternator shall be as per OEM standard. Alternator shall be brushless, self-excited, digital automatic voltage regulator, class H insulation, double bearing AC generator in accordance with IS: 4722 with latest amendments with screen protected drip proof enclosure and damper winding on pole faces.

Insulation class of alternator shall be of H but temperature rise shall be limited F. Space heater shall be provided for 250kVA and above rated alternator. 2 numbers per phase thermisters with temperature scanner shall be provided for 500kVA and above rated alternator. Terminal box shall be suitable to terminate number of cables for respective rating, necessary terminal extension box shall be considered as per requirement.

D. Battery

Set of staring batteries consisting of required nos. of 12/24 V and of required AH capacity VRLA SMF (Valve regulated lead acid, sealed maintenance free) batteries connected in series with first charge of electrolyte with leads, lugs and terminals etc. duly installed on MS frame near the Engine.

Battery Charger

DG set shall be with offline battery charger and suitable to charge the battery when DG is on.
Battery Charger shall be consisting of

- Transformer and rectifier with surge protection network
- DC Voltmeter
- DC Ammeter

Selector switch for Trickle, off and boost and current adjustment

E. Base Frame

The Engine and Alternator should be assembled on a sturdy fabricated, adequately machined base frame, made out of high quality MS channels. The base frame should be provided with lifting facilities and drilled foundation holes suitable for installation in concrete foundation with anti-vibration mounting. DG set is to be supplied with anti-vibration mountings pad suitable for the DG set load.

F. Fuel Tank

Day fuel tank of adequate liters capacity with inlet and outlet pipe connections, filling cap, drain plug, level indicator and floor mounting pedestal along with hand operated fuel transfer pump and suitable hose.
The fuel tank shall be inbuilt part of the DG set. The fuel tank shall be suitable for minimum 8 hours of operation of DG set on full load. However, maximum fuel tank capacity shall be 990 liters.

G. Control Panel

The specifications for control panel of DG set shall be as per specifications of LV panels as described in full details in relevant section.

Panel for DG shall be designed and constructed as per stipulations and provisions specified therein.

The accessories shall also be provided as shown in section of specifications for LV panels.

Construction parameters, accessories etc. shall also be as per LV panel specifications.

Apart from standard accessories, DG control panel shall have following minimum additional accessories.

a) TNC/Breaker control switch (for ACB incomer)
b) Digital voltmeter and voltmeter selector switch (0-500V)
c) Digital ammeter and ammeter selector switch
d) Current transformers Resin cast for metering and protection. Cl 0.5, 10 VA.
e) Digital type Multi-function Meter shall be with 3 line display, LCD, Accuracy Class: 0.5 Suitable for measuring and displaying the following parameters: A,V,F,PF,KW,KWH, KVA, KVAR, KVARh, Md, Harmonic & with inbuilt RS 485 communication port. (Schneider- EM 6400NG; L&T – MFM 4420; Secure – Elite 445; equivalent model of other approved make). Data sheet with parameter comparison shall be submitted for approval.
f) Power factor meter.
g) Freuqency meter
h) Auto/Manual, Local/ Remote selector switch.
i) Emergency stop Push button.
j) LED Indicating lamps

Besides standard accessories following are to be provided as per governing standards and actual requirement.

k) Battery Charger consisting of following.
    - Transformer and rectifier with surge protection network
    - DC Voltmeter
    - DC Ammeter
    - Selector switch for Trickle, off and boost and current adjustment

l) Electronic AMF/AMF Cum Synchronizing Logic relay (Nb2 or Equivalent) to cover the following functions as a minimum.
    - Mains supply failure monitor
    - Supply failure timer
    - Restoration timer
    - 3 impulse Automatic engine Start/Stop attempts
    - Failure to start indication
    - Off/Manual/Auto/Test Selectors
    - Power On/Off Switch
    - Synchronizing relay with load sharing arrangement with arrangement to change over MASTER (for AMF cum Synchronizing Panel)

Sr. No.	Condition	Indication	Alarm	Trip Annunciation
	Phase Indicating lamps ON, OFF, TRIP			
1	Mains on	Yes		---
2	Generator on	Yes		---
3	Load on Mains	Yes		---
4	Load on generator	Yes		---
5	Auto/Manual	Yes		
6	Common Fault		Yes	
7	Over and Under Voltage		Yes	
8	Battery Charger Fault		Yes	
9	Low Fuel Oil Level		Yes	
10	Over Load		Yes	
11	Low Lub Oil Pressure	Yes		Yes
12	High Water Temperature	Yes		Yes
13	High Lub Oil Temperature			Yes
14	Set fails to start (with alarm)	Yes	Yes	Yes

Special Notes

Up to 70kVA rating the engine can be air cooled type and above 70 kVA rating engine shall be water cooled type.

70kVA and above rating, the engine shall have turbo charged aspiration.

Above 500kVA, the engine shall have turbo charger with after cooling.

The diesel engine generator set shall be with acoustic enclosure.

The diesel engine can be naturally aspirated, turbocharged type or turbocharged with after cooler arrangement type as per respective manufacturers' standards.

H. Acceptance Test

Following tests shall be carried out for DG set and control panel by the vendor to the entire satisfaction of the purchaser at manufacturers' works.

a) Phase I Test

- Insulation resistance test
- Continuity test
- High voltage test on power wiring of control panel
- Visual examination to ensure that the DG set, accessories, control panel etc. are provided for the finish and general appearance of the work as per specifications/tender

- Dimensions and alignment
- A no load test for a period of five minutes to see that the engine, alternator and other accessories are functioning normal

b) Phase II Test

- On successful completion of the phase I tests full load test will be carried out for 30 minutes continuously by loading artificially.
- The overall efficiency of the DG set at ¼ load, ½ load and full load shall be worked out.
- All necessary arrangements for testing under artificial load conditions such as cables, electrodes, load and consumable like diesel, lubricating oil etc. shall be provided by the OEM/vendor.

c) Documents Requirements

- Alternator manufacturers' routine test certificate/prime power rating documents.
- Engine manufacturer's routine test certificate/MoEF certified power (BHP) documents.
- Calibration/test certificates with setting manuals of manufacturers' of ACB/MCCB, meters, all instruments and relays shall be presented for review during inspection and shall be part of dispatch documents.
- Transient response test for sudden application and rejection of loads of 25%, 50%, 75% and 100% of rated capacity.
- Wave form test (type test results are acceptable).
- Vibration and Noise level test shall be provided after installation at site.

I. Specific Requirement

The vendor should be in possession of type and routine test certificates as per IS issued by CPRI or any other testing laboratories and ISO 9001 certificate.

On receipt of purchase order the vendor shall submit the following drawings for approval before manufacturing.

a) General Arrangement Drawing
b) Foundation Drawing
c) Cable Termination Details
d) GTP, BOQ, GA drawing, Power and Control Wiring Drawing of Control Panel of DG set

The scope of work shall include all transportation of the DG sets and its accessories to the site of work with utmost care in handling. All loading and unloading arrangements with necessary plants/equipment and tools shall be the part of the scope and all required man power shall also be provided by the vendor for unloading/shifting of the DG set to the DG room and installing in position as required.

Supply and laying of power and control cable between DG set and control panel is including in the scope of work.

The vendor shall be responsible for all the safe custody of the DG sets and its accessories from the time of supply of DG sets at site till installation, testing and commissioning and handling over the same to Client on satisfactory completion of work.

The DG vendor shall coordinate with other agencies during the course of the installation testing and commissioning of the DG set and shall provide all supervision if any required to guide for safe commissioning of the DG Set.

The installation work shall be started and completed immediately once the readiness of site is intimated to the DG vendor without any further delay.

All minor civil works like opening in wall for exhaust pipe and fuel pipe etc. required for installation of DG sets is included in the scope of the ccontractor/vendor.

The work of installation, testing and commissioning of DG set shall be done by qualified and competent Engineer/Supervisor and all instructions shall be strictly followed for the completion of work with good workmanship as required and as per IE rules and regulations of Statutory body and other mandatory requirements.

The vendor has to supply the following items free of cost on commissioning of the DG set.

- Technical literature, control and power circuit diagram, manufacturers' manual of engine, alternator, panel etc. in number of sets as specified.
- List of essential spares.
- One set of essential maintenance tools like grease gun, tool kit with Ratchet spanner set, torque wrenches, Allen keys etc.

The routine test of engine and alternator shall be arranged at manufacturers' premises by the vendor. Prior intimation shall be given regarding the readiness of engine and alternator for conducting the routine test as per relevant IS standards.

Load testing of the entire installation or load as available (minimum 40% of DG rating preferred) at site, shall be carried out at site, on commissioning of the DG set.

Contractor/Agency shall be responsible for obtaining necessary statutory approval for installation and operation of DG set (Electrical Inspector, Central/Local Pollution Control Board etc.).

5.0 INSPECTION & TESTING

Inspection of offered equipment/items at manufacturers' works' shall be done by the Client/ PMC/TPI as specified here in as per relevant inspection and testing standards and as per approved, quality assurance plans, technical data sheets, SLD, documents and drawings.

Inspection Criteria of Various Major Equipment/Items at Manufacturers' Works:
Major electrical equipment/items as specified below, shall be tested and inspected at vendor manufacturers' works as narrated, prior to dispatch to ensure compliance with the specifications,requirements and applicable codes and standards and approved quality assurance and testing plans by the Client/PMC/TPI.

- **HV Panels/RMU**

  100% quantity of HV breaker panels and RMU, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.
  100% quantity of **HV FCMA/HFSR/VFD starter panels**, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **LV Panels**

  100% quantity of LV panels for **Amperes Ratings ≥ 630 Amps,** tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **VFD Stand Alone and MCC Panels with VFD**

  100% quantity of VFD stand alone panels and all LV panels with VFD starters irrespective of **Amperes Ratings,** tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **APFC Panels**

  100% quantity of APFC panels for **KVAr Ratings ≥ 100 KVAr,** tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **Transformers**

  100% quantity of transformers for **kVA Ratings ≥ 500 KVAr,** routine tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **DG Sets**

  1 No. of each for kVA Ratings **≥ 500 kVA,** tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **HV Cable**

  For all types, ratings and sizes of HV cables, if the quantity of each size, type and where length of cable is **≥ 250 meters,** tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **LV Cables**

  For all types, ratings and sizes of LV cables, if the quantity of each type and size **≤ 120 sq. mm** and where length of cable is **≥ 1000 meters,** tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.
  Similarly For all types, ratings and sizes of LV cables, if the quantity of each type and sizes **> 120 sq. mm** and where length of cable is **≥ 500 meters,** tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **HV Motors**

  100% quantity of motors of each type and rating of entire lot, routine tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI. Type test of one motor of each typa and rating out of entire lot, shall also be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **LV Motors**

  Motors ≤ 45 kW: Routine tests carried out internally and type test certificate of identically rated motor **≤ 45 kW** shall be submitted for review and acceptance by the Client/PMC/TPI.

  Motors > 45 kW to < 160 kW: For motor ratings **> 45 kW**, **one motor** of each type and rating out of the lot shall be sent to pump manufacturer for performance testing of pump-motor assembly set, while all other motors in the lot shall be subjected to internal routine tests. Routine test certificates

and type test certificate of identically rated motor shall be submitted for review and acceptance @ the time of pump-motor assembly performance test.

OR

Out of all motors rated **> 45 kW to < 160 kW**, **25% quantity of motors of each type and rating or one number (whichever is higher)** out of entire lot, routine tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI and routine tests of all other motors carried out internally and type test certificate of identically rated motor shall be submitted for review and acceptance.

Motors ≥ 160 kW: For motors rating **≥ 160 kW, 25% quantity of motors of each type and rating or one number (whichever is higher)** out of entire lot, routine tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI. **Type test of one motor of each rating** out of entire lot, shall also be witnessed @ Manufacturers' works by the Client/PMC/TPI. Routine tests of all other motors carried out internally shall be submitted for review and acceptance.

- For all major equipment/items specified above, where factory inspections are exempted as clearly specified above, all tests as per relevant and applicable standards as well as approved QAPs, data sheets, SLD, documents and drawings must be carried out by the manufacturers'/vendors/panel builders etc. and test certificates, As built drawings and BOM, MTCs etc. shall be submitted to the PMC/TPI prior to dispatch for getting dispatch clearance of the Client/PMC/TPI.

- All other items shall be cleared for dispatch based on review of material test certificates/ manufacturers' test reports' by the Client/PMC/TPI.

All expenditure pertaining to inspection including to and fro travel, local conveyance, lodging and boarding etc. shall be borne by the Contractor for minimum 2 representatives of Client/PMC/TPI Agency.

The Client or his authorized representative may visit the works during manufacture of various electrical equipment/materials to assess the progress of work as well as to ascertain that only quality raw materials are used for the same. He shall be given full assistance to carry out stage inspection. Client's representative shall be given minimum two weeks advance notice for witnessing the final testing.

Field tests as per approved procedures/procedures available with Engineer-in-charge or his authorized representative shall be performed on the electrical system/equipment before it is being put into service. All test equipment shall be arranged by the Vendor/Contractor. Test reports shall be approved by the Engineer-in-charge before acceptance of the equipment and complete plant.

6.0 ELECTRICAL INSTALLATION

This specification covers the technical requirements for equipment, materials and installation methods, testing and commissioning of electrical system.

The contractor shall possess a valid electrical contractor's license for the state in which site is located and shall ensure its validity during the duration of the contract.

The contractor shall employ adequate skilled and unskilled labour to complete all work according to programme of work. Skilled workers shall possess the minimum qualifications stipulated by statutory or competent authorities.

The contractor shall employ adequate numbers of supervisor to control the labour force and to carry out the work as per schedule. Supervisory staff shall also possess the minimum qualifications stipulated by statutory and competent authorities.

Various types of equipment shall be installed in accordance with approved drawings and/or manufacturers' instructions and good engineering practices. Particular attention shall be paid to lubrication of moving parts and bearings, alignment, tightness of all connections (mechanical and electrical) and wiring.

The transformers and DG sets shall be moved to its location and shall be correctly positioned on their bases.

All parts of the transformers, which are supplied loose, such as conservator, radiator banks, buchholz relays, dial thermometers, bushings, etc. shall be fitted onto the transformers.

Transformer oil if supplied in drums shall be filled into the transformer after duly testing/filtering, up to the correct level required. The transformer may have to be dried out and oil filtered.

The contractor shall place the switchgear correctly on the base of foundation prepared for the same. If the switchgear consists of a switchboard with number of panels bolted together, he will place all the sections of the switchboard correctly, align them and bolt the sections together to form one continuous switchboard. The switchgear shall then be secured to the foundation by means of nuts and bolts or foundation bolts grouted in the base. The contractor shall also make inter section bus/wiring connections.

In case of wall/structure mounted equipment, boards, the contractor shall fabricate and install the structural steel frame work suitable for mounting the various equipment boards. The contractor may have to prepare drawing showing the proposed general arrangement, of the structural frame which shall be subject to the approval of the Enginee-in-charge. The fabrication and installation of the framework shall be recommended only after the approval of drawings. Various items of the equipment, board shall be mounted in accordance with the approved drawings.

Motor shall generally be installed by others, along with the driven equipment. The contractor may, however, be asked to install motors in specific instances.

Cable routes and mode of installation shall generally be as shown in the construction drawings.

Identification tags indicating cable designation, shall be affixed to each cable at ends and at an interval not exceeding 15 meters or at the location where cables change direction or elevation. Signboards with necessary indication/arrow mark with necessary structure/foundation shall be also be installed, of adedquate size as approved by Engineer-in-charge, for the entire cabling system buried underground.

HV XLPE/PVC armoured cables shall be terminated or jointed by means of cold setting epoxy based cast resin jointing system or heat shrinkable or push on type cold setting kit.

All cable glands should be of nickel plated brass, double compression type. All Alu/Cu cables shall be terminated through crimping type Alu/Cu lugs respectively.

All electrical equipment viz. transformers, switchgear, motor control centers, motors, control stations, switches, lighting, fittings and other electrical apparatus shall be connected to the main earth loop by means of two separate and distinct external earth conductors. The material, type and size of earth conductors will be as shown in the drawings or as specified.

Electrical installation in hazardous areas if applicable as defined in IS: 5571 shall be carried out with utmost care and special precautions shall be taken to ensure operational safety.

All personnel, especially supervisory staff, working on such installations shall be fully conversant with the applicable National Standards and Code of Practice and shall have previous experience of such work.

The contractor shall take all reasonable safety precautions during construction and testing of the works. Particular attention shall be paid to the following:

a) To prevent any conductor or apparatus becoming accidentally or inadvertently charged.

b) Prior to electrical installation (or part there of) being connected to the main supply, the Contractor shall ensure that uncommissioned or incomplete circuits cannot be inadvertently energized and completed circuit cannot be used without the Engineer's consent.

c) No hot work is carried out without work-permit issued by the Engineer in FLP zones (if stipulated by process application).

The tests specified below/elsewhere as part of this tender document shall be carried out on the electrical equipment and installation before commissioning the same. The tests shall be performed by or under the direct supervision of a competent person, qualified to carry out the tests. All tests shall be carried out in the presence of the authorized representative of the Employer/Owner and/or the Engineer, unless this stipulation is waived in writing.

7.0 PAINTING

All surfaces of equipment/structural steel shall be sand blasted, degreased and pickled in acid as required to provide a smooth & clean surface, free of rust/scale/grease.

After cleaning the surface shall be given one coat of high quality red oxide or yellow chromate and baking in the oven (for equipment only).

All surfaces shall be then finished with 2 (two) coats of finished epoxy based paint of shade 631 of IS: 5 or with a paint shade of Client's choice unless otherwise specified.

8.0 DETAILS OF TESTS

I POWER and DISTRIBUTION TRANSFORMERS

i) Check HV and LV cable terminations, ground connections, fittings and accessories, oil level and oil leaks at various joints. Check breather, thermometers and buchholz relay for proper functioning and operation. Check junction box, marshalling box etc. for correct wiring.

ii) Oil Test

Crackle test and dielectric test as per Clause 7.11 of IS: 10028. The oil shall withstand at least 40kV with a gap of 4mm.

iii) Insulation Resistance Test

This may be carried out on new transformer without drying out the transformer, provided the transformer has not been idle or stored for a long period. Otherwise, this test shall be carried out during drying out of transformers. Insulating resistance test shall be carried out between primary & secondary to ground as well as between primary and secondary. Windings not under test shall be grounded during the test.

A megger rated 1000V or higher shall be used for the test.

iv) Polarity and Phasing Out Test

Check external connection of the transformer in accordance with diagram of connection and phase sequence (anti-clockwise)

II HV AND LV SWITCH GEAR

i) Check proper mechanical operation of circuit breakers including alignment of trolleys in case of draw out type circuits breakers, smooth operation of all mechanical parts, lubrication, mechanical interlocks etc.

ii) Check contact alignment and wipe, proper sequence of closing and opening of main and arcing contacts.

iii) Check electrical relays, instruments and controls for correct wiring.

iv) Insulating test on bus bars – phase to phase and phase to ground. This test will be carried out with circuit breakers in service position, but contacts remaining open.

v) Insulation test on relays & control wiring including current and potential transformers and wiring of CT and PT secondaries.

vi) Insulation test on circuit breakers in withdrawn position – phase to phase and phase to ground with contacts closed.

vii) Adjust correct settings of relays and/or direct acting trips - as specified.

viii) Operation test

Energise only control circuits and carry out closing and tripping operations (where AC supply derived from main supply is used for operation, the switch–gear bus may be energised). Check operations of electrical interlocks. Check tripping of circuit breakers by manual operations of protective relays contacts. Check operations of mechanical closing and tripping devices. Check lockout conditions for closing of circuit breakers by simulating the required conditions. Check control, indications, sequence interlocks and alarms.

ix) Polarity and connections of instrument transformers – Check for correctness of CT and PT connections provided. Check electrical continuity of secondary with ELV tester.

x) Check operation of instruments, meters, relays and tripping of circuit breakers by primary/ secondary injections as specified.

xi) Check continuity of power circuits and earth continuity of all non current metallic parts with a low voltage a (6 volts or less) continuity tester.

III MOTOR CONTROL CENTRES, SWITCHGEARS

i) Check equipment, internal wiring, smooth mechanical operation, interlocks etc.

ii) Check continuity of power circuits and earth continuity of all non current carrying metallic parts with a low voltage continuity tester.

iii) Insulation test for power and control circuits between phases, between phases and neutral and between phase/neutral and ground.

iv) Check operation by energizing control circuits (without energizing power circuits) for correct functioning. Simulate eternal controls and interlocks for the same. Note chatter or humming of contactor and rectify, in necessary.

v) Check fuse ratings and adjust relay setting (overhead, single phasing preventers etc) in accordance with load ratings.

vi) Polarity and connections of instrument transformers – Check for correctness of CT and PT connections provided. Check electrical continuity of secondary circuits with ELV tester.

IV MOTORS AND ROTATING EQUIPMENT

i) Check equipment for free movement of rotor, and play, lubrication and for any other visual checks.

ii) Insulation test of motors – between winding and ground. Use 500V megger for MV motors and 1000V megger for HV motors.

iii) Check electrical continuity with ELV tester.

iv) No load running of motor noting down no load current and voltages in all three phases.

V CABLES

i) Insulation Test between each phase and neutral and between each phase/neutral and ground.

ii) DC high voltage test on HV cables in accordance with the relevant Indian Standards and Code of Practice. This test shall be carried out on cables installed in final positions, and all joints and terminations have been made. The cables, however, may not be connected to the equipment, so that the equipment may not be subject to the test voltage.

iii) In case of lighting wiring, insulating test shall be carried out on lighting feeders with branch circuits open. Branch circuits shall be tested separately with lamp holders, plug receptacles and lighting fittings in position, but without lamps. In case of lighting circuits will lamp ballasts and glow starters, insulation resistance may be measured between phase and ground only.

iv) In case of directly buried cables, insulate resistance of cables shall be measured before and after the back fillings.

v) Test all receptacles for correct phase sequence.

VI EARTHING SYSTEM

i) Measure earth resistance of each electrode separately. If a number of earth electrodes are interconnected with one another, combined earth resistance shall also be measured. The earth resistance of each electrode and/or a group of electrodes shall not exceed the values specified.

ii) Carry out line earth loop impedance test. The loop comprises the line conductor from the point of fault, back to the supply transformer, the path through transformer winding, the earthed neutral point of the transformer and path for that point to the point of fault through the earthing system.

iii) Continuity test for earth continuity conductors with ELV tester.

9.0 STATUTORY APPROVALS

The Contractor shall be totally responsible for obtaining statutory approval from the electrical inspector or any other statutory authority for the entire installation including DG Set carried out by him unless otherwise specified and agreed. Necessary test reports shall be submitted by him to electrical inspector. This will be an integral part of the contract and shall not be paid for separately. **The contractor shall liaison with local electric supply company for getting power supply and only necessary fees, if any, payable to supply company shall be borne by the Owner.**

10.0 ACCEPTANCE OF INSTALLATION/ERECTION

On completion of the work the Engineer-in-charge, together with the Contractor, will carry out an inspection of the Installation. The Engineer-in-charge will issue a completed copy of the Client's Acceptance of Electrical Installation to the Contractor as confirmation that the works have been accepted, subject to any matters noted on the form being attended to.

11.0 PRICE BREAKDOWN

1.1 Whenever requested by the Engineer-in-charge, the contractor shall furnish detailed price breakdown for supply and installation of each of the items of electrical works including for each type/size of applicable cable/light fitting/earth pit/earth stations.

1.2 This breakdown prices are required for the purpose of justification for progress payment and also for working out addition and deletion, if any, in the scope of work at a later date.

12.0 VENDOR DATA REQUIREMENTS

Following minimum documents shall be submitted by contractor along with the bid as well for review and approval during detailed engineering, as indicated.

Sr. No.	Description	With Bid/ Offer	For Review/ Approval	As Built
1	Technical Details for Major Equipment		*	*
2	List of Recommended Spares		*	*
3	Data Sheets/GA drawings/BOM/SLD/Wiring and Schematic Diagrams for Power and Control Circuit/Data sheets of Relay for 11kV HV VCB Panel/Transformers/Motor/Bus Duct/DP Structure as applicable		*	*
4	GA Drawings with sectional view, door open view, top and bottom view, Rear view, Mounting plate details etc./BOM/SLD/Wiring and Schematic Diagrams for Power and Control circuit for LV Panel/Starter/APFC Panel/Bus Duct		*	*
5	Technical Data Sheet/Catalogue of ACB, MFM, Soft Starter, VFD, APFC Relay, Detuned Reactor		*	
6	GA Drawing/BOM/Technical Details for LCS/Indoor and Outdoor Light Fixtures /LDB/Switch Board/Safety Equipment		*	*
7	Data Sheet and BOM for Cable Tray		*	*
8	Cable Schedule/Data Sheet/Make and Type for HV/LV Power and Control Cables.		*	*
9	Earthing (Grounding) System Calculation and Details		*	*

10	Lightening Protection System for Buildings and Structures (If and as Applicable)			
11	RCC Foundation Details for various Electric Equipment.		*	*
12	Inspection Schedule and QAPs for Major Equipment		*	
13	Test Certificates		*	*
14	O and M Manual (If and As Applicable)		*	*

13.0 DATA SHEETS (TO BE FILLED & SUBMITTED BY BIDDERS/VENDORS)

Data sheets duly filled and certified by the Bidder/Vendor for various major equipment are to be submitted by the Bidder/Vendor along with all other required documents/drawings etc. as narrated above are to be submitted for approval by the Client/PMC/TPI prior to execution.

DATA SHEET FOR HV (11 kV) VCB BREAKER PANEL

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
1.0	**General**		
1.1	Make	As per Approved vendor list	
1.2	Model and Type	Pl. furnish	
1.3	Design Ambient Temperature	50 ^{0}C	
1.4	Atmosphere	Humid	
1.5	Location	Indoor/Outdoor	
1.6	Degree of Protection	IP 5X/As per tender	
1.7	Quantity and Configuration (Incoming and Outgoing)	As per tender Pl. furnish	
2.0	**Electrical Data**		
2.1	Type of Breaker	Vacuum Circuit Breaker	
2.2	Service	Continuous	
2.3	Rated Voltage/Frequency/ Number of Phase	11kV ± 10% /50 ± 5% Hz/3	
2.4	Maximum System Voltage	12kV	
2.5	System Earthing	Solidly Earthed	
2.6	System Fault Level	350/500 MVA or higher as per Statutory requirements	
2.7	Rated Short Time Current	18.37/26.3kA (1 second) or higher as per Statutory requirements	
2.9			
2.10	Auxiliary Supply (Power Pack Required)	110V DC derived from Power Pack connected on 110V AC PT supply.	
2.11	Making capacity	46kA (peak)	
2.12	Busbar Material and Current Rating	Copper and 400 / 630 / 800 Amps. as per SOQ	

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
2.13	Cable Entry	Bottom	
2.14	Cable Termination Space Required For	3C x 300 sq mm XLPE Al. Armoured Cable	
2.15	**Breaker Particulars**		
	(a) Operating Duty	Pl. furnish/Show Catalogue/IS	
	(b) Operating Mechanism	Motor Charged Spring/Manual Trip and Close	
	(c) Spring Charging Motor	230V AC, 200W	
	(d) Trip/Closing Coil	110V DC, 180W	
	(e)Anti Pumping Feature /Relay	Required	
	(f) Latching Requirement	Trip Free	
	(g) Emergency Trip Push Button	Required	
	(h) Space Heater and Cubicle Lighting	Required	
2.16	**Constructional Requirement**		
	(a) Thickness of sheet steel for frame, enclosure, doors, covers and partitions	CRCA sheet 2mm, hinge type door with neoprene rubber gasket	
	(b) Colour	Epoxy Powder Coating RAL 7035	
	(c) Earth bus Size	40mm x 6mm Tinned Copper	
	(d) Foundation Frame	ISMC 100 Suitable for three breakers or as per BOQ with necessary bed plate and foundations bolt	
	(e) Over All Dimension	Provide Dimensions	
	(f) Over Load of Equipment	Provide as per tender	
	(g) Minimum Clear Space required for (i) Front Side: (ii) Rear Side:	Provide Dimensions	
2.17	Annunciation	As per Specifications	
2.18	Relays	As per Specifications	
	(a) Relay No. and Detail	As per Specifications	
	(b) Type of Relay	As per Specifications	
	(c) Make of Relay	As per Specifications	
	(d) Model No of Relay	Provide Details	
2.19	Current Transformer		
	(a) Type of CT	Cast Resin	
	(b) Accuracy class	As per Specifications	
	(c) VA Burden	As per Specifications/Requirement	
	(d) CT Ratio	As per Specifications/Requirement	
2.20	Potential Transformer		

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
	(a) Type of PT	Cast Resin	
	(b) Accuracy class	As per tender	
	(c) VA Burden	As per Specifications/Requirement	
	(d) PT Ratio	As per tender	
2.21	**Panel Accessories**		
b)	Toggle Switch for Space Heater and Socket	230V AC, 6 A	
c)	(b) Socket	6 Pin 5/15 A with DP MCB	
d)	(c) MCB for Spring Charging Motor Circuit	6A , DP MCB	
e)	(d) MCB for ON/OFF	Double Pole, 16A, 110V DC for DC Circuit and Double Pole, 16A, 230V AC for AC Circuit	
f)	Local/Remote Selector Switch	4 ways, 2 positions, lockable in any position, angular movement, stay put, lever type handle	
g)	Trip – Neutral – Close (TNC) Switch.	6 ways, 3 position, spring return to neutral, angular movement, lockable pistol grip type handle	
h)	Space Heater	230V AC , 100W (LV supply from LV panel)	
i)	Limit switch for test and service position.	Required	
j)	Danger Notice Plate	With Sign of Skull and Bones as per IS-2551	
k)	Technical Name Plate	Power supply voltage, Control supply voltage, Panel fault level, Panel protection class etc.	
l)	HV Panel Name Plate	Name of Client (on first row/top row), Project name (second row), name of Contractor (third row) and Panel manufacturer (in fourth row)	

DATA SHEET FOR HV (11 kV) RMU PANEL

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
1.0	**General**		
1.1	Make	As per Approved vendor list	
1.2	Model and Type	Metal enclosed panel type, compact (Pl. furnish)	
1.3	Design Ambient Temperature	50 ^{0}C	
1.4	Atmosphere	Humid	
1.5	Location	Outdoor	

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
1.6	Degree of Protection	IP 5X/As per tender	
1.7	Quantity and Configuration	As per tender Pl. furnish	
2.0	**Electrical Data & Service Conditions**		
2.1	Service	Continuous	
2.2	Rated Voltage/Frequency/ Number of Phase	11kV ± 10% /50 ± 5% Hz/3	
2.3	Maximum System Voltage	12kV	
2.4	Power frequency withstand voltage	28 kV	
2.5	Impulse withstand voltage	95kVp	
2.6	Rated peak withstand current capacity	50kA	
2.7	Rated Short Time Current	26kA (1 second) or higher as per Statutory requirements	
2.8	System Earthing	Solidly Earthed	
2.9	System Fault Level	500 MVA or higher as per Statutory requirements	
2.10	Auxiliary Supply	Pl. furnish	
2.11	Busbar Material and Current Rating	Copper-630 Amp/as per BOQ	
2.12	Insulating Gas	SF6	
2.13	Nominal operating (Rated) Gas pressure	1.4 bar (Pl. furnish)	
2.14	Minimum (Absolute) gas Filling Pressure	1.05 bar (Pl. furnish)	
2.15	Cable Arrangement & Entry	Cable Box/Bottom (Pl. furnish)	
2.16	Cable Termination Space Required For	Minimum 3C x 300 sq mm XLPE Al. Armoured Cable	
2.17	**Load Break Switch (LBS)/ Isolator & VCB Particulars**		
	(a) Operating Duty	Pl. furnish	
	(b) Operating Mechanism	Motor Charged Spring/Manual Trip and Close (Pl. furnish)	
	(c) Spring Charging Motor	Pl. furnish	
	(d) Trip/Closing Coil	Pl. furnish	
	(e) Latching Requirement	Trip Free	
	(f) Emergency Trip Push Button	Required	
2.18	**Constructional Requirement**		

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
	(a) Thickness of SS for frame, enclosure, doors, covers and partitions	Stainless Steel Minimum 2mm, hinge type door with neoprene rubber gasket	
	(b) Colour	Epoxy Powder Coating/As per specifications/Manufacturer standards	
	(c) Earth bus Size	Pl. furnish	
	(d) Foundation Frame Details	Pl. furnish	
	(e) Over All Dimension	Pl. furnish	
	(f) Minimum Clear Space required for (i) Front Side: (ii) Rear Side:	Pl. furnish	
2.19	**Relays**	Self Power IDMT O/C & E/F (Pl. furnish following details)	
	(a) Relay No. and Detail		
	(b) Type of Relay		
	(c) Make of Relay		
	(d) Model No of Relay		
2.20 (a)	Current Transformer		
	(a) Type of CT	Cast Resin	
	(b) Accuracy class	As per Specifications	
	(c) VA Burden	As per Specifications/Requirement	
	(d) CT Ratio	As per Specifications/Requirement	
2.20 (b)	Potential Transformer		
	(a) Type of PT	Cast Resin	
	(b) Accuracy class	As per tender	
	(c) VA Burden	As per Specifications/Requirement	
	(d) PT Ratio	As per tender	
2.21	**Interlocking Facility 50 kA**		
	(a) Between 11 kV line side isolator “ON” & earthing	Required	
	(b) Between 11 kV DT/feeder side breaker “ON” & earthing	Required	
2.22	**RMU Accessories**		
a)	Space Heater and Cubicle Lighting	Required (Pl. furnish details)	
b)	Toggle Switch for Space Heater and Socket	230V AC, 6A	
c)	Socket	6 Pin 5/15 A with DP MCB	
d)	MCB for Spring Charging Motor Circuit	6A , DP MCB	

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
e)	MCB for ON/OFF	Double Pole, 16A, 110V DC for DC Circuit and Double Pole, 16A, 230V AC for AC Circuit	
f)	Local/Remote Selector Switch	4 ways, 2 positions, lockable in any position, angular movement, stay put, lever type handle	
g)	Trip – Neutral – Close (TNC) Switch	6 ways, 3 position, spring return to neutral, angular movement, lockable pistol grip type handle	
h)	Annunciation	Pl. furnish	
i)	Fault passage indicator	Required as per specifications	
j)	Anti Reflexing Handle	Required as per specifications	
k)	SF6 gas pressure gauge & filling arrangement	Required as per specifications	
l)	Capacitive voltage indication (VPIS)	Required	
m)	Right angle boot sets	Required	
n)	Circuit Label	Required	
0)	Mimic Diagram	Required	
p)	Any other details (if any)	Pl. furnish	
q)	Danger Notice Plate	With Sign of Skull and Bones as per IS-2551	
r)	Technical Name Plate	Power supply voltage, Panel fault level, Panel protection class etc.	
s)	RMU Panel Name Plate	Name of Client (on first row/top row), Project name (second row), name of Contractor (third row) and Panel manufacturer (in fourth row)	

DATA SHEET FOR DISTRIBUTION TRANSFORMER

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
1.0	**General Features**		
1.1	Make	As per tender	
1.2	Rating in kVA	As per BOQ	
1.3	Installation/Position	Outdoor/Platform (Plinth) Mounted	
1.4	Service	Continuous	
1.5	Climate	Hot, Humid, Dusty/Corrosive	
1.6	Type of Cooling	ONAN (Oil Natural Air Natural)	
1.7	Ambient Temperature	Maximum 50 ^{0}C/Average 35 ^{0}C	
1.8	Allowable Temperature Rise	As per IS: 1180 (Part 1)	

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
1.9	Painting	Epoxy, Shade Siemens Grey RAL 7035	
1.10	Oil Type	Mineral Oil	
1.11	Type of Mounting/Position	Platform (Plinth) Mounted	
2.0	**Electrical Data**		
2.1	Earthing (LV Side)	Solid	
2.2	No. of Windings/Material	Two/Copper	
2.3	Phase and Frequency	3 and 50 Hz	
2.4	System Voltage: Nominal/Highest	11kV/12kV	
2.5	(a) Voltage Ratio	11/0.433kV	
	(b) Voltage Variation	±10%	
	(c) Frequency Variation	±3%	
	(d) Combined Voltage & Frequency Variation	±10%	
2.6	Phase Connection (HV/LV)	Delta – Star	
2.7	Vector Group	Dyn – 11	
2.8	Creepage Distance	31mm/KV	
2.9	Winding Insulation and Class	Uniform (HV and LV) and A	
2.10	Terminations: a) HV Side b) LV Side	a) Cable Box/11 kV(E) 3C X suitable size Al. XLPE cable as per BOQ b) Busduct / Cable Box/1.1kV 3 ½C suitable size Al. XLPE cable as per SOQ	
2.11	LV Box Busbar Size	Maximum Copper Current density considered 1.4 A/mm²	
3.0	**Tap Changer**		
3.1	Tappings	On HV Side	
3.2	Tap Changer	~~Off Circuit **(< 2000**kVA)~~ OLTC ~~**(≥ 2000**kVA~~) OR as specified in SOQ	
3.3	Tap Range	As per IS: 1180 Part 1 (2021)/± 10%/ SOQ	
3.4	Number of Steps	As per IS: 1180 Part 1 (2021)/in range of 2.5% for Off Circuit and 1.25% for OLTC/As per SOQ	
4.0	Limit for Transformer Operation Under Over Load Conditions as per IS	Pl. furnish	

Bidders' stamp & initials

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
5.	**Accessories** **1)** Inspection Cover, **2)** Buchholz Relay with Alarm and Trip Contacts (for Ratings ≥ **250**kVA), **3)** Marshalling Box of IP 55 class of protection, **4)** Sampling Valve with Plug or Cover Plate, **5)** Magnetic Oil level Gauge and Plain Oil Level Indicator with Minimum Mark, **6)** Conservator and Conservator Drain Valve, **7)** Bi-Directional Rollers, **8)** Oil Temperature Indicator with Alarm and Trip Contacts, **9)** Bottom Drain and Filter Valve with Plug/Cover Plate, **10)** Double Diaphragm Explosion Vent, **11)** Silica Gel Breather, **12)** Inspection Cover, **13)** Marshalling Box of IP 55 class of protection, **14)** Sampling Valve with Plug or Cover Plate, **15)** Magnetic Oil level Gauge and Plain Oil Level Indicator with Minimum Mark, **16)** Air Release Plug/ Device, **17)** Separate Neutral Bushing, **18)** Top Oil Filter Valve, **19)** Jacking Pads, **20)** Lifting Lugs, **21)** 02 Earthing Terminals, **22)** Thermometer Pocket for OTI,	Required	

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
	23) Winding Temperature Indicator with Alarm and Trip Contacts, **24)** Pressure Relief Valve (for Ratings ≥ **2000**kVA), **25)** Rating and Diagram Plate and **26)** Neutral CTs for REF and Back up E/F Protection (for Ratings ≥ **2000**kVA).		
	OLTC and RTCC Panel with AVR (For Transformers Ratings ≥ **2000**kVA/**if specified in SLD/BOQ**) **Oil Surge Relay** (for Ratings ≥ **2000**kVA/**if specified in SLD/SOQ**) Any other required as per IS: 1180/IS: 2026		
6.0	**Performance Data**	Pl. furnish	
6.1.	Guaranteed Maximum Total Losses without Positive Tolerance (No Load + Load Losses at 75 ^{0}C) at **100%** of **Rated Load**	IS: 1180 Part-1 (2021) up to ≤ 2500kVA Minimum Level 2/For higher ratings As per Specifications/SOQ	
6.2	Guaranteed Maximum Total Losses without Positive Tolerance (No Load + Load Losses at 75 ^{0}C) at **50%** of **Rated Load**	IS: 1180 Part 1 (2021) up to ≤ 2500kVA **Minimum Level 2**/ For higher ratings As per Specifications/SOQ	
6.3	Impedance (Percentage) on **Principal Tap**	IS: 1180 Part 1 (2021) up to ≤ 2500kVA **Minimum Level 2**/For higher ratings As per Specifications/SOQ	
6.4	Rated Current a) No Load Gurrent at 100% Voltage b) No Load Current at 112.5% Voltage	As per IS: 1180 Part 1 (2021) 2% of Full Load Current 5% of Full Load Current	

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
6.5	Rated Efficiency at 0.8 PF a) At full load b) At 100% load c) At 50% load	As per IS: 1180 Part 1 (2021) Pl. furnish	
6.6	Rated Regulation a) At 0.9 PF lag b) At 0.8 PF lag c) At Unity PF	Pl. furnish	
6.7	Load at which Maximum Efficiency Occurs	Pl. furnish	
6.8	Maximum Efficiency	Pl. furnish	
6.9	Permissible Flux Density and Over Fluxing	As per IS: 1180 Part 1 (2021) Pl. furnish	
6.10	Current Density	Pl. furnish	
7.0	**Mechanical Data**	Pl. furnish	
7.1	Total Quantity of Oil	Pl. furnish	
7.1A	Extra oil	10% Extra oil in Non returnable drum	
7.1B	All Hardware	Hot Dip GI	
7.2	a) Transformer Weight (With Oil) b) Transformer Weight (Without Oil) c) Copper weight d) Core Weight	Pl. furnish Pl. furnish Pl. furnish Pl. furnish	
7.3	Dimensions of Transformer including All Accessories (L X W X H in mm)	Pl. furnish	
7.4	Recommended Dimensions of Plinth for Transformer (L X W X H in mm)	Pl. furnish	

DATA SHEET FOR LOW VOLTAGE PANEL BOARD

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor & be submitted at the time of Drawings
1.0	**Site Conditions**		
1.1	Type/Make	Indoor/As per tender	
1.2	Mounting	Floor	
1.3	Design Ambient Temperature	50 ^{0}C	
1.4	Atmosphere	Corrosive, Humid and Dusty	
2.0	**Construction**		
2.1	Housing	2.0 mm thick CRCA sheet for Body, Partition, Cover/Door	
2.2	Protection Class	IP 5X	
2.4	Base Channel	100mm x 50mm x 5mm	
2.5	Shipping Section Length	2500mm (Max)	
2.6	Side Sheets for Shipping Section	Full side sheet on both side of shipping section	
3.0	**Operating Conditions**		
3.1	Voltage	415V ± 10%	
3.2	Number of phase	3	
3.3	System	3 Phase, 4 wire	
3.4	Frequency	50Hz ± 5%	
3.5	Fault Current	50kA as per SLD	
3.6	Neutral Grounding	Solid	
4.0	**Control System**		
4.1	Voltage		
	For Indication	230V AC	
	For Metering	230V AC	
	For Protection	230V AC	
4.2	Control Supply Through Constant Voltage Transformer	230VAC for PMCC and APFC only	
4.3	Wiring	Control Wiring: 1.5 mm² FRLS PVC Cu flexible Wire (Grey); CT wiring 2.5 mm² Color Coded	
5.0	**Bus Bar**		
5.1	Phase Bus Bar Material	EC Grade Aluminium	

5.2	Neutral Bus Bar Material	Same as Phase Bus Bar	
5.3	Earth Bus Bar Material	65mm x 10mm (Hot Dip Galvanised Strip) Or 40mm x 10mm (EC Grade Al)	
5.4	Current Density	1 sq. mm = 0.8 A Maximum. Size of Bus Bar based on Design Temperature, kA Level and Minimum Current Density	
5.5	Hard Ware	High Tensile Steel Bolts, Nuts and Washers duly Zinc/Cd Passivated shall be used for all Bus Bar Joints and Supports.	
6.0	PLC Based System	As per SLD/SOQ	
7.0	**ACB**		
7.1	Type, Rating, Number of Poles	EDO, 50kA Rating and Pole as per SLD	
7.2	Protection	LSIG with Display and Fault Record Display	
7.3	Display of Metering	Basic (A,V,F) and Energy for I/Cand and Only Current Display of Outgoing	
7.4	Communication Port	Inbuilt RS 485 (on MODBUS/ Ethernet)	
7.5	Model	Schneider Master pact NW or Siemens 3WL or L & T U power or ABB E-Max; or Equivalent Model from Approved Vendor list	
8.0	**MCCB (Ics = 100% Icu)**		
8.1	Incomer and Bus Coupler MCCB	Microprocessor based Release with O/L, S/C, inbuilt E/F, 50 kA, 4 pole	
8.2	Outgoing MCCB		
8.21	For rating above 200 A	Microprocessor based Release with O/L, S/C, inbuilt E/F, 50kA, 3/4 pole as specified in SLD	
8.22	For rating up to and including 200 A	Thermal Magnetic based Release with Adjustable O/L, Adjustable S/C, 50kA, 3/4 Pole	
8.23	For SS/VFD Starter Feeder MCCB	Microprocessor based Release with O/L, S/C, inbuilt E/F, 50kA, 3/4 Pole as specified in SLD	
8.24	Accessories	Extended Rotary Handle, Terminal Spreader, Auxiliary Change Over Contact + Trip Contact: To be provided	

9.0	**Electronic Motor Protection Relay (with RS 485 Port)**		
9.1	Type	Electronic MPR with LCD display (3 Phase Current), Record Storage, DI/DO interface etc. as per Detailed Specifications with RS 485	
9.2	Protection/Interface	Confirm the following	
		1) Over Current 2) Short Circuit 3) Earth Fault 4) Current Unbalance 5) Phase Loss/Reversal 6) Under Current (Dry Run) 7) Stall (Bearing Broken) 8) Locked Rotor 9) Ground/Earth Fault/Leakage (ZCT) 10) Single Phasing with Under Voltage and Over Voltage 11) Over Temperature (With PTC Thermister) 12) 3 Programmable DI and 2 Programmable DO 13) Fault Record, Start/Stop, Run Hrs. Maximum Starting Current Record	
10.0	**Painting**		
10.1	7 Tank Process, 2 Coats of Primer, Oven Baked at 310 ^{0}C with Powder Coating	Required	
10.2	Colour and Shade and Thickness: Panel Exterior and Interior	RAL 7035 Thickness: Minimum 100 Micron	
10.3	Mounting Plate	Glossy White	
11.0	**Current Transformer**		
11.1	Type	Resin Cast	
11.2	Class of Accuracy	Cl: 0.5 for MFM, APFC Load Sensing, Summation, MPR Cl: 1 for Ammeter	
11.3	Burden (VA)	As per Specifications	
12.0	Control Wiring	FRLS PVC Copper Flexible 1.5 sq. mm: control wiring 2.5 sq. mm: CT wiring	

13.0	Hardware	For Bus Bar Joints High Tensile With Zink Passivation/Cd Plated	
14.0	Space Heater	230V AC witht Thermostat	
15.0	Pocket For Drawings at Door	Yes	
16.0	Instrumentation Compartment	Separate compartment for Energy Meter, Hour Meter, Level Controller, etc. with necessary Internal Wiring	
17.0	Panel Internal Lighting	LED light 3 W with Auto NO contact/switch with panel door for VFD/SS/Starter feeder. 3 W LED Panel light ½ ft long with Control MCB for internal lighting for incomer/ cable alley	
18.0	Danger Notice Plate	With Sign of Skull and Bones as per IS-2551	
19.0	Technical Name Plate	Power supply voltage, Panel fault level, Panel protection class etc.	
20.0	RMU Panel Name Plate	Name of Client (on first row/top row), Project name (second row), name of Contractor (third row) and Panel manufacturer (in fourth row)	

Note: Other specifications not mentioned in datasheet shall be considered as per tender specification/ SLD.

INDUCTION MOTOR

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
1.0	Make	Pl. furnish	
2.0	Application	Pl. furnish as applicable	
3.0	Type	TEFC Squirrel Cage Induction	
4.0	Efficiency Class	IE3 as per IS: 12615 (2018)	
5.0	Ambient Temperature	50 ^{0}C	
6.0	Degree of protection	IP 55	
7.0	Pump Shaft BKW in kW	Pl. furnish	
8.0	Motor Ratings in kW	Please furnish	
9.0	Number of Units/Quantity	As per BOQ/Tender	
10.0	Supply Neutral	Solidly Earthed	
11.0	Rated Voltage	415 V	
12.0	No. of Phase and Frequency	3 Phase and 50 Hz.	
13.0	Full Load Amperes A	Pl. furnish	
14.0	Supply Conditions	± 10% Voltage Variation	

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
		± 5% Frequency Variation ± 10% Combined Variation	
15.0	Synchronous Speed	As per SOQ/Tender	
15.0	Duty Conditions as per IS: 12615 or Equivalent	S1 suitable for continuous operations	
16.0	Method of Starting	DOL/Star Delta /Soft Starter/VFD as applicable	
17.0	Guaranteed Motor Efficiency @ Full Load @ 3/4 load @ ½ load	Motor shall be IE 3 (as per BOQ) as per IS: 12615 (2018) Pl. furnish	
18.0	Power Factor @ Full Load @ 3/4 load @ ½ load	As per IE 3 as per IS: 12615 (2018) Pl. furnish	
19.0	Starting Torque % of Full Load Torque	Sufficient starting torque to start maximum full load of driven equipment Pl. furnish.	
20.0	Pull Out Torque % of Full Load Torque	Sufficient to bring the motor to normal speed in min. time. Pl. furnish	
20.1	Starting Time at specified minimum starting voltage (Sec)	Pl. furnish (As per Tender)	
20.2	Permissible Running Time at Full Load at Minimum Allowable Voltage (Min.)	Pl. furnish (As per Tender)	
21.0	Locked Rotor Current ithstand Time (Safe Stall Time) at 110% rated voltage	Pl. furnish (As per Tender)	
22.0	At Rated Temperature (Hot)	Pl. furnish (As per Tender)	
23.0	When Cold	Pl. furnish (As per Tender)	
24.0	Class of Insulation and Temp. Rise by Thermometer	Pl. furnish (As per Tender)	
25.0	Design Temperature	50 ^{0}C	
26.0	Location	As per Tender	
27.0	Hazardous Area Division	As per Tender	
28.0	Atmosphere	As per Tender	
29.0	a) Type of Cooling b) Type of Enclosure c) Degree of Protection	Pl. furnish Pl. furnish **For Motor and TB Minimum IP 55**	
30.0	Terminal Box	As per Manufacturers' Standards	
31.0	Earthing Terminals	Required as **per IS Minimum 2 no.**	
32.0	External Cable Details	As per the SLD/Tender	
33.0	Shaft: Hollow/Solid	Pl. furnish (As per Tender)	
34.0	Type of Couplings	Pl. furnish (as per Tender)	

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
35.0	Type of Bearings	Pl. furnish (As per Tender)	
36.0	Colour Shade of Paint	Epoxy Grey shade 632 as per IS: 5	
37.0	Space Heater for Motors	Confirm as per SLD/SOQ/Tender	
38.0	RTD/BTD	For 90kW and above motors (6 nos: for winding temperature, 2 nos. for bearing temperature and 2 nos. Spare)	
39.0	Winding Connections	6 Terminals	
40.0	Marking and Labelling	Marking on Rating plate as per 10 of IS: 15999 (Part 1)	
41.0	Applicable Standards to be followed	IS: 12615 (2018), 15999, 8225, 4889, 4772, 4029, 4691 and other relevant IS or Equivalent Standards.	

DIESEL GENERATING SET

Sr. No.	Particular	Details	Confirm/Data to fill by the vendor
1	Engine Make	As per Vendor List	
2	Rating & Duty	As per tender/SOQ & prime duty	
3	Quantity	As per tender/SOQ	
4	RPM	1500	
5	Voltage, Ambient Temperature, PF and Loading	415V, Ambient Temperature 50 ^{0}C for Engine and 40 ^{0}C for Alternator, 0.8 PF (lag) and 80% Loading	
6	Voltage Regulation	± 1% of rated voltage for any loads between no load to full load.	
7	Voltage Dip (Sudden Load Application 0.0% to 100% at PF 0.8)	-5%, Recovery Time: 0.25 second	
8	Frequency	50Hz	
9	Prime Mover	Diesel Engine	
10	Fuel Consumption	At 100%, 75% & 50% Load	
11	Service	Prime Mover for Generating Set	
12	Diesel Engine Standards	ISO 3046	
13	Air Intake System	Air intake manifold dry type air cleaner vacuum indicator	
14	Exhaust System	Turbo Charger Exhaust Manifold (Hospital Grade)/In Residential areas with Two Nos. Silencer)	
15	Lubricating System	Engine Mounted Lube Oil Pump Lubricating Oil Filter	
16	Fuel System	Fuel Pump with Electronic Governor and Replaceable Fuel Filter	
17	Starting System	24V DC Electric Starter and 24V DC Battery Charging Alternator	

18	Control Panel with Switchgears and Relays	Required as per tender	
19	DG Set Controller	Microprocessor based with RS 485 Modbus for interface with SCADA/ PLC	
20	Controls Required	Off/Manual/Auto Control Switch, Emergency Stop, Manual Run/Stop Control Switch, Panel Lamp/Lamp Test Control Switch Adjustment for time delay start/stop & Alternator voltage/Frequency.	
21	Metering		
A	For Engine	Starting, Battery Voltage, Lube Oil Pressure and Engine Coolant Temperature	
B	Electrical Parameters	Current, Voltage, Frequency, kW, KWH, PF, kVA	
21	Protection/Warning		
A	Engine Protection	Over Speed Shut down Low Lube Oil Pressure Warning/Shut down Low Coolant Level Warning/Shut down Low Coolant Temperature Warning Low and High Battery Voltage Warning Dead Battery Shutdown Over Crank Shutdown Fail to Crank Shutdown	
B	Alternator	Over Current Warning Shutdown Short Circuit Shutdown High/Low Voltage Shutdown Under/Over Frequency Shutdown/ Warning Reverse Power (kVA & KVAr) Shutdown	
22	Alternator Make	As per approved vendor list	
A	Alternator Standards	BS 2613/IS: 4722	
B	Enclosure	IP 23	
C	Insulation	Class 'H'	
D	Rating	Ambient Temperature 40 ^{0}C and Insulation Class H Temperature Rise Limited to Class F	
23	Engine Speed Governing Control	To provide Isochronous Engine Speed within ± 0.25% for only steady state load from no load to full load	

24	Flywheel with Housing	Yes	
25	Vibration Damper	Yes	
26	Acoustic Hood	Yes	
27	Coupling	Yes	
28	Full Load Fuel Consumption per Hour	DG Vendor to provide	
29	Fuel Tank	14 SWG sheet metal with drain valve, air vent, inlet & outlet connections	
30	Fuel Tank Capacity	As per tender (Maximum 990 litres)	
31	Fuel Tank Installation	Floor Mounting (Outside Acoustic Enclosure)	
32	Engine Testing At Vendor's Works At Site of Plant	Yes	
32	Tool Kits	To be Provided	
33	Documents (Two Sets Each) Operation and Maintenance Manual, Parts Catalogue /List, Test Certificates of Diesel Engine, Alternator and DG Set	Yes	

Notes: 1) Manufacturer/supplier shall submit separate data sheet for each duty/rating along with rating determination calculations as per tender specifications.
2) Other specifications not mentioned in datasheet, shall be considered as per tender specifications/relevant governing IS/Other Norms and Statutory Requirements.

14.0 APPROVED VENDOR LIST – ELECTICAL EQUIPMENT AND COMPONENTS

ITEM DESCRIPTION	APPROVED MAKE
COMPACT SUBSTATIONS	ABB / CGPIL / SCHNEIDER / SIEMENS / BHEL / C & S
DISTRIBUTION TRANSFORMERS	ABB / AREVA / BBL / BHEL / CGL / EMCO / GEC / KEC / SCHNEIDER / RAYCHEM RPG LTD. / TRANSFORMERS & RECTIFIERS INDIA LIMITED / VOLTAMP / POWERLITE
TRANSFORMER LIGHTING - DRY TYPE (CAST RESIN)	ABB / AUTOMATIC ELECTRIC LTD. / CGL / INDCOIL / KOTSONS / VOLTAMP
MV SWITCHBOARD & SWITCHGEAR MV - 11 / 33kV - INDOOR / OUTDOOR TYPE (VCB/SF6)	ABB / AREVA / BHEL / CG POWER / GEC / JYOTI / L & T / SCHNEIDER / SIEMENS / AUTH. SYSTEM INTEGRATOR FOR SPECIFIED / APPROVED MAKE OF OEM
RING MAIN UNIT (RMU) MV - 11 / 33kV - INDOOR / OUTDOOR TYPE (VCB/SF6)	ABB / BHEL / CG POWER / GEC / JYOTI / L&T / SCHNEIDER / SIEMENS
PROTECTIVE RELAYS (NUMERICAL TYPE)	ABB / ALSTOM / CGPIL / GE / L & T / SCHNEIDER / SIEMENS / CSPC (C & S)

PROTECTIVE / AUXILLARY RELAYS (ELECTROMECHANICAL TYPE)	ABB / ALSTOM / CSPC (C & S) / EASUN REYROLLE / GE / GEC L & T / SCHNEIDER / SIEMENS / CGPILL
ELECTRONIC CIRCUIT RELAY	ALLEN BRADLEY / OEN / OMRON / PLA
CONTROL AND RELAY PANEL	ABB / ALSTOM / EASUN REYROLLE / L & T / SCHNEIDER / SIEMENS
INSTRUMENT TRANSFORMERS (CT / PT/CBCT)	AEP / ASHMOR / AUTOMATIC ELECTRIC / CGPIL / CONTROL & SWITCHGEAR / ECS / GILBERT AND MAXWELL / INDCOIL / JYOTI / KAPPA / PRAGATI / PRECISE / SILKAANS
LV SWITCHBOARD - DRAWOUT / FIXED TYPE (PCC-LVDB / PMCC / MCC / MLDB / MPDB / MOVDB / APFC)	ABB / ALPHA NIPPON / C & S / CGL / ELEMBICA / ELEMECH / HORIZON / INDUSTRIAL CONTROLS / L & T / PATEL BROTHERS / POSITRONICS / POWER & INSTRUMENTATION (O) LTD. / SCHNEIDER / SIEMENS / SUN AUTOMAT / SWATI SWITCH GEAR / HIGH VOLT / ALSTOM / JYOTI / G SONS POWER / POWERTECH SWITCHGEARS (I) PVT. LTD. / CORE METAL KRAFTS LTD / EXPEL PROSYS PVT. LTD. / SAMUDRA POWER PRODUCTS / SHIVSHAKTI ENGINEERS / ANY OTHER MANUFACTURER WHO MEETS THE REQUIREMENT SPECIFIED AT NOTE NO. 1 BELOW.

Note No. 1:

Any LV Panel Manufacturer meeting/possessing the following requirements as a minimum shall also be qualified as an approved vendor for supply of LV Panels:

1. Should have obtained approval from CPRI/ERDA and obtained type test certificate for LV Panel with rated voltage of 415V (3 Phase + N), 50Hz rated frequency and Minimum 3200A rated current and having short circuit withstanding strength of Minimum 65kA for one second.
2. Should have obtained approval from CPRI/ERDA and obtained type test certificate for Degree of Protection Class IP-55 or above for LT Panel with rated voltage of 415V (3 Phase + N), 50Hz rated frequency and certificates must have validation for current year.
3. The company should be in existence for Minimum 5years and shall have GST Registration Certificate.
4. Shall have ISO 9001:2015 or latest amended up to date certified.
5. The panel manufacturer should have minimum average turnover of 3 Crores for similar panels manufacturing in last Two (2) financial years (Trading or contracting turnover shall not be considered), duly certified by Chartered Accountant.

Necessary supporting documents/copy of certificates duly notarized shall be submitted along with self attested undertaking for manufacturing facilities on panel manufacturer's letter head (by Bidder submitting bid as panel manufacturer or by the Bidder who is proposing to supply panel or carry out panel related work from such manufacturer). Client reserves the right to inspect the works facility of such panel vendor at any stage of bid/execution to assess the facility and verifying the requirements as specified above (The cost of such visit by Client officials of up to two persons including travel, lodging, boarding, local conveyance etc. shall be borne by the Bidder). Further Bidder and vendor (LV panel manufacturer) to note that at any stage if it is observed that the LV panel vendor's details submitted are incorrect or fake or forged, Client reserves right to initiate action against such Bidder/Vendor including keeping their registration with Client in abeyance for up to 3 years or as decided by the concerned authority of Client.

AIR CIRCUIT BREAKERS	ABB / L & T / SCHNEIDER / SIEMENS / LEGRAND / C & S / MITSUBISHI
MCCB'S	ABB / C & S / GEC / L & T / SCHNEIDER / SIEMENS / LEGRAND / MITSUBISHI

SWITCH DISCONNECTOR FUSE UNIT (SDF) AND SWITCH DISCONNECTOR ISOLATOR	ABB / C & S / GEC / L & T / SCHNEIDER / SIEMENS / INDOASIAN / MITSUBISHI
CHANGE OVER SWITCH	BCH / C & S / GE POWER / HAVELLS / HPL / KRAUS & NAIMER / L & T / SCHNEIDER / SIEMENS
SOFT STARTER (MICRO PROCESSOR BASED)	ABB / CG POWER (EMOTRON) / DANFOSS / ROCKWELL / SCHNEIDER / SIEMENS / L&T
VVVF DRIVES (VFD)	ABB / CG POWER (EMOTRON) / DANFOSS / ROCKWELL / SCHNEIDER / SIEMENS / YASKAWA
MV CAPACITORS	ABB / EPCOS / SHREEM / UNIVERSAL / VISHAY
LV CAPACITORS / POWER CAPACITOR	ABB / EPCOS / HAVELLS / ASIAN / BHEL / CGL / GEC / KHATAU JUNKER / MADHAV / MALDE / NEPTUNE / SCHNEIDER / UNIVERSAL / SHREEM / PRABODHAN / POWER MATRIX / SIEMENS / VISHAY / SUBODHAN
DETUNED SERIES REACTORS WITH TEMPERATURE MICRO SWITCH (HARMONIC FILTER REACTOR)	EPCOS / WHEPL / YESHA / NEPTUNE / VISHAY / SUBODHAN
DYNAMIC POWER FACTOR CORRECTION THYRISTOR MODULE	EPCOS / SCHNEIDER / NEPTUNE / SUBODHAN
APFC PANEL	ABB / DATAR / EPCOS / L & T / NEPTUNE / SCHNEIDER / ASIAN / CGL / EASUN / ALSTOM / CSPC / SIEMENS / ALL APPROVED VENDORS FOR LT PANEL
APFC RELAY/CONTROLLER	ABB / DATAR / ENERCON / EPCOS / L & T / SCHNEIDER / SIEMENS / NEPTUNE / CUMMINS / SYNTEL / TRINITY / SELEC
CAPACITOR DUTY CONTACTOR	ABB / EPCOS / L & T / SCHNEIDER / SIEMENS / C & S
MICROPORCESSOR BASED MOTOR PROTECTION RELAY WITH RS 485	CSPC (C & S) / ABB / L & T / SCHNEIDER / SIEMENS / EXCEL-TECH INDIA / PROK DEVICES /
AC/DC POWER & AUXILLARY CONTACTOR	ABB / BCH / C & S / GE / L & T / SCHNEIDER / SIEMENS / INDO ASIAN
BI-METAL / ELECTRONIC / MICROPROCESSOR BASED OVERLOAD RELAY	ABB / GE / L & T / SCHNEIDER / SIEMENS / CSPC (C & S) / ALSTOM / CG / INDO ASIAN
THERMISTER RELAY	ALSTOM / INSTA CONTROLS / MINILEC / SELEC
SINGLE PHASING PREVENTER WITH UV/OV PROTECTION	ABB / C & S / GE / L & T / MINILEC / SCHNEIDER / SIEMENS
TIME SWITCH	GIC / LEGRAND / SCHNEIDER / SIEMENS / THEBEN
TIMERS / TIME DELAY RELAY	BCH / EAPL / L & T / LEGRAND / MINILEC / OMRON / PLA / SCHNEIDER / SIEMENS / TEKNIC / THEBEN / ELICO / INDO ASIAN
MOTORS (LV)	ABB / BBL / BHEL / CG POWER / JYOTI / KEC / MARATHON / SIEMENS / LHP
BATTERY CHARGER & DCDB	AMARA RAJA / AMCO POWER / AUTOMATIC ELECTRIC / CALDYNE AUTOMATICS / CHHABI ELECTRICALS / EXIDE / HBL POWER SYSTEMS / HIREL-HITACHI / MASS-TECH CONTROLS / UNIVERSAL INSTRUMENTS / SERVILINK / ELECTRONIC SYSTEMS

LIGHT FIXTURES	BAJAJ / C & S / CGL / GE / HAVELLS / PHILIPS / SURYA / WIPRO / SCHREDER / L & T / TISVA (USHA INTERNATIONAL LIMITED)
CABLES HV - XLPE INSULATED	HAVELLS / KEI / NICCO / POLYCAB / PRIMECAB (RAVIN CABLES) / RPG CABLES (KEC International) / TORRENT CABLES / UNIVERSAL / ASIAN CABLE / CCI / GLOSTER / FINOLEX
LT POWER & CONTROL CABLES / EARTHING CABLES	AVOCAB / CCI / FINOLEX / HAVELLS / KEI / LAPP / NICCO / POLYCAB / PRIME CAB (RAVIN CABLES)/ RPG CABLES (KEC INTERNATIONAL) / RR KABEL / TORRENT / UNIVERSAL CABLES / ASIAN CABLE / GLOSTER
WIRES - FLEXIBLES (ALL TYPES)	AVOCAB / FINOLEX / KEI / L & T / LAPP / POLYCAB / RR KABEL / UNIVERSAL / ANCHOR / HAVELLS / ATLAS / GLOSTER
LIGHTING / SMALL POWER DISTRIBUTION BOARDS / ENCLOSURES	ABB / BCH / C & S / ELDON / ENCLOTEK / HENSEL / INDO ASIAN / L & T / LEGRAND / RITTAL / SCHNEIDER / SIEMENS / HAVELLS / STANDARD ELECTRIC / ALL LV PANEL VENDORS
MCB, RCCB, RCBO / MCB ISOLATORS	ABB / C & S / INDO ASIAN / L & T / LEGRAND / MOELLER / SCHNEIDER / SIEMENS / GEC / HAVELLS / C & S / INDO ASIAN / MITSUBISHI
MPCB	ABB / C & S / L & T / SCHNEIDER / SIEMENS / INDO ASIAN / MITSUBISHI
ALARM ANNUNCIATORS (SOLID STATE TYPE WITH LED ILLUMINATION) / FACIA ANNUNCIATOR	ALSTOM / DIGICONT / ICA / IICP / MINILEC / PROCON INST. (P) LTD / PROTON ELECTRONICS / APLAB
DECORATIVE / MODULAR SWITCH & SOCKET	ABB / ANCHOR / CLIPSAL / CRABTREE / L & T / LEGRAND / MK - HONEYWELL / SIEMENS / SCHNEIDER / INDO ASIAN / HAVELLS / TOYAMA / MDS
CEILING/WALL MOUNTING/ EXHAUST FANS	ALMONARD / BAJAJ / CGL / HAVELLS / KHAITAN / ORIENT / USHA / ATOMBERG
CABLE TERMINATION/JOINTING KITS	3M / ABB KABELDON / M SEAL / RAYCHEM / XICOM / CCI
CONTROL / SELECTOR SWITCH	ABB / ALSTOM / BCH / GE POWER CONTROLS / HAVELLS / KAYCEE / L & T / SCHNEIDER / SIEMENS / RECOM / SULZER / EE / JYOTI
INDICATING LAMPS	BCH / L & T / SCHNEIDER / SIEMENS / TEKNIC CONTROLS / VAISHNO / IEC / EE
TERMINAL BLOCK/CONNECTORS	CONNECTWELL / ELMEX / PHEONIX / TELEMECHANIQUE / WAGO
CONSTANT VOLTAGE TRANSFORMER/CONTROL TRANSFORMER	AE / ASHMORE / G & M / INDCOIL / NEC / PRAGATI / PRECISE / SILKAANS
SEMICONDUCTOR FUSE	BUSSMANN / FERRAZ / GE / SIEMENS
HRC FUSE (POWER & CONTROL)	ABB / C & S / L & T / SCHNEIDER / SIEMENS / TECHNOELECTRIC / INDO ASIAN / GE
PUSHBUTTONS	BCH / L & T / RASS / SCHNEIDER / SIEMENS / TEKNIC / VAISHNO
PUSH BUTTON STATIONS/ JUNCTION BOX (FOR CAST ALUMINIUM ONLY)	BALIGA / BCH / CEAG / EXPROTECTA / FCG FLEXPRO / HANSU / HENSEL / PUSTRON / SCHNEIDER / SIEMENS / SUDHIR / EXCEL

NON METALLIC ENCLOSURES (INCLUDING INDUSTRIAL RECEPTACLES / PB STATION)	BCH / HENSEL / LEGRAND / PUSTRON / RITTAL / SCHNEIDER / SIEMENS / SINTEX
DIGITAL AMMETER / VOLTMETER/ POWER FACTOR METER	AE / KRYKARD / L & T / MASIBUS / RISHABH / SCHNEIDER / SECURE / ALSTOM / NIPPEN / ASIAN / SIEMENS / IMP / MECO / CONZERV / NEWTEK ELECTRICALS / SELEC
TEMPERATURE SCANNER WITH RS 485 MODBUS COMMUNICATION	MASIBUS / NIVAM / NISHKO / ELECTRONET / REDIX / MULTISPAN / SELEC
ELECTROMECHANICAL METERS – AMMETER & VOLTMETER	AE / IMP / MECO / RISHABH / SELEC
KWH / LOAD MANAGER / MULTI FUNCTION METER	ABB / KRYKARD / L & T / SCHNEIDER / RISHABH / SECURE / IMP/ MECO / CONZERV / ENERCON / SELEC
CABLE LUGS	3D / COMET / CONNECTWELL / DOWELLS / JAINSON / 3M
CABLE GLANDS (SINGLE / DOUBLE COMPRESSION, NI-PLATTED BRASS)	BALIGA / BRACO / COMET / ELECTROMEC / EX-PROTECTA / FCG / HMI / JAINSON / SIEMENS / SUDHIR
CABLE GLANDS – POLYAMIDE	FIBOX / GEWISS / HENSEL / LAPP
LIGHTNING ARRESTORS	CGL / ELPRO / JAYSHREE / OBLUM / WS / BIRLA NGK INSULATORS / JEF / DHRUVA
SURGE SUPPRESSORS	ABB / EMERSON / ERICO / MTL / OBLUM / PEPPERL+FUCHS / PHOENIX / SCHNEIDER / SIEMENS / WEID MULLER / REYCHEM
UNINTERRUPTED POWER SUPPLY (UPS)	ABB / EMERSON / FUJI / HITACHI / INVENSYS / SCHNEIDER / SOCOMEC
GI / FRP CABLE TRAYS, ANY OTHER FRP ITEMS	GLOBE / INDIANA / JACINTH / LEGRAND / M.M. ENGINEERING / SHARDA / SILVERLINE POWER / SHREE KRISHNA ENGG. / VATCO / SUPER ELECTRO / SUMIP / FIBER TECH COMPOSITE / SATYAM COMPOSITES / DUDHAT INFRA / KISMAT ENGITECH LLP
UPVC CONDUIT & ACCESSORIES	AKG / CLIPSAL / L&T / POLYCAB / PRECISION / SALZER / BHAGYALAXMI PIPE INDUSTRY / ANY OTHER FOR UPVC PIPES AS PER MECH VENDOR LIST
MS / GI CONDUIT & PIPES	BEC INDUSTRIES / JINDAL / JK TUBE / SAIL / TATA STEEL / ZENITH / ANY OTHER FOR MS/GI PIPES AS PER MECH VENDOR LIST
SMF / VRLA / NI-CD / LEAD ACID (PLANTE / TUBULAR) BATTERY	AMARA RAJA BATTERIES LTD / AMCO / EXIDE / HBL POWER SYSTEMS LTD / AUTOMATIC ELECTRIC
MS / GI LIGHTING POLES & BRACKETS (TUBULAR SWAGED / OCTAGONAL)	AMBICA POLES PVT LTD / BAJAJ / BOMBAY TUBES AND POLES / GAYATRI ELECTRICALS / INDIA ELECTRIC POLES / RIDDHI POLES / SHAKTI POLES / SURYA / SHREE KRISHNA ENGG. / UTKARSH INDIA / FABIRON /KISMAT ENGITECH LLP
HIGH MAST LIGHTING SYSTEM	BAJAJ / CGL / PHILIPS / SURYA / VALMONT
SANDWICH BUS TRUNKING (BUS DUCT)	C & S / SCHNEIDER / SIEMENS / L & T/ ABB

CONVENTIONAL BUSDUCT	ABB / C & S / L & T / SCHNEIDER / SIEMENS / STARDRIVE / ALL LT PANEL VENDORS
DIESEL ENGINES	ASHOK LEYLAND / CATERPILLAR / CUMMINS / KOEL / MAHINDRA POWEROL / MITSUBISHI / PERKINS / VOLVO / WARTSILA / BAUDOUIN
ALTERNATORS FOR DG SETS	BHEL / CGL / JYOTI / KEC / KOEL / LEROY SOMER / NGEF / STAMFORD
AMF RELAY, SYNCHRONIZING RELAY (WITH RS 485)	DEEP SEA / C & S / WOODWARD / DEIF
HANDHELD DIGITAL MULTIMETER / CLIP-ON METER / MEGGER	FLUKE / IMP / MECO / MOTWANE / RISHABH
BATTERY BACKED POWER PACK	ALAN / G'LEC / BHARANI / GOGATE
ALUMINIUM BUSBAR MATERIAL	BANCO / HINDALCO / JINDAL / STERLITE
COPPER BUSBAR MATERIAL	HINDALCO / JINDAL / STERLITE
PANEL CRCA / MS / GI PLATES & SHEET	ESSAR / TATA / JINDAL / SAIL
CHEMICAL TYPE EARTHING INCLUDING COPPER BONDED ELECTRODE & BACK FILL COMPOUND	ASHLOK / CURSP / ECO TECHNOLOGY & PROJECTS / ENNOV INFRA / ERICO / ISG GLOBAL / PRAGATI ELECTROCOM / SAARA EARTHING / JEF / EQUIVALENT REPUTED MAKE SUBJECT TO CLIENT APPROVAL
ACTIVE HARMONIC FILTER SOLUTION / PANEL	ABB / DANFOSS / SCHNEIDER / AMTECH / EPCOS / CONSULE NEOWATT / SCHNEFFER / SUBODHAN /AB LIFASA / NEPTUNE / FUJI ELECTRIC / SHREEM / TRINITY
PANEL VENTILATION FAN	HICOOL / REXNORD / NADI / COOLTRON

The contractor shall distinctly understand that it will not be their perogative to insist on a particular brand from the list, and final selection will be done with the approval of Engineer-in-charge.

Note: It is not the intent to specify herein completely, all details pertaining to design, shop testing, installation, field testing and commissioning. However, these shall conform in all respects to high standards of engineering design and workmanship, meeting the requirements of all applicable codes and standards including local statutory requirements. The scope shall include all the specified accessories/items as well as other any required items/accessories, whether specified or not, for satisfactory/safe operation of the entire electrical system and for meeting all statutory requirements.

APPLICABLE NATIONAL/ INTERNATIONAL STANDARDS

AGA : American Gas Association, Gas Measurement Committee

ANSI/ASME : American National Standards Institute/American Society of Mech. Engineers

B 1.20.1	Pipe Threads
B 16.5	Steel Pipe Flanges and Flanged Fittings
B 16.20	Ring Joint Gaskets and Grooves for Steel Pipe Flanges

ANSI/FCI : American National Standards Institute/Fluid Controls Institute

70.2 : Control Valve Seat Leakage Classification

API : American Petroleum Institute

RP 520	: Sizing, selection and installation of pressure relieving systems in refineries. Part-I - Sizing and selection Part-II - Installation
RP 521	: Guide for pressure relieving and depressurising systems
RP 526	: Flanged steel safety relief valves
RP 527	: Seat tightness of pressure relief valves
MPMS	: Manual of Petroleum measurement standards
RP 551	: Process measurement instrumentation Part - I Process Control and Instrumentation
RP 552	: Transmission Systems
S 2000	: Venting atmospheric and low pressure storage tanks
S 670	Vibration, Axial-Position and Bearing Temperature Monitoring Systems

ASTM : American Society for Tests and Materials

BS : British Standards

BS-1042	: Measurement of Fluid Flow in Closed Conduits
BS-5308 Part-II	: Specification for PVC insulated cables
BS-7244	: Breather Valves

DIN :Deutsches Institut für Normung

DIN-43760	: Temperature Vs. Resistance curves for RTDs
DIN-19234	: Electrical Distance Sensors; DC interface for distance sensors and signal converter
DIN-50049	: Document on Material Testing

IEC : International Electro technical Commission

	IEC 79	: Electrical apparatus for Explosive Gas atmosphere
	IEC 85	: Thermal evaluation and classification for electrical insulation
	IEC 332	: Test on bunched wires or cables Part III Cat. A
	IEC 529	: Classification of degree of protection provided by enclosures
	IEC 534-2	: Industrial Process Control Valves - Flow capacity
	IEC 584-2	: Thermocouples - Tolerances
	IEC 751	: Industrial Platinum Resistance Thermometer Sensors
	IEC 801	: Electromagnetic compatibility for industrial process measurement and control equipment
IS	: Indian Standard	
	IS-5	: Colours for ready mixed paints
	IS-319	: Specification for free cutting brass bars, rods and sections
	IS-1239	: Mild Steel tubes, tubulars and other wrought steel fittings
	IS-1271	: Specification of Thermal Evaluation and Classification of Electrical Insulation
	IS-1554 Part-I	: PVC insulated (heavy duty) electrical cables – working Voltage upto and including 1100V
	IS-2074	: Ready mixed paints, air drying, red oxide - zinc chrome
	IS-2147	: Degree of protection provided by enclosures for low Voltage switch gear and control gear
	IS-2148	: Flame proof enclosures for electrical apparatus
	IS-3624	: Specification for Pressure and Vacuum gauges
	IS-5831	:PVC insulation and sheath of electric cables
	IS-7358	: Specification for Thermocouples
	IS-8784	: Thermocouple compensating cables
ISA	: Instrument Society of America	
	S-5.2	: Binary logic diagrams for process operations
	S-7.3	: Quality standard for instrument air
	S-75.01	: Flow equations for sizing control valves
ISO 5167	: Measurement of fluid flow by means of orifice plates, nozzles and venture tubes inserted in circular cross-section conduits	
NACE	: National Association of Corrosion Engineers - MR-01-75	
NEC	: National Electric Code	
NEMA	: National Electrical Manufacturer’s Association	
ICS-6	: Enclosures for industrial control and systems	
NFPA	: National Fire Protection Association	

NFPA-496 : Purged and pressurised enclosures for electrical equipment

OSHA : Occupational Safety and Health Authority

GENERAL PRINCIPLES

The contractor shall carryout all works wholly in accordance with the terms and conditions of the contract to fulfill the requirement of the project. All the material used, and the equipment installed shall be as per the specifications defined in the contract and the work shall be executed with good engineering practices.

Bidder shall adopt / adhere to below general engineering specifications and practice while designing / supplying the proposed system. The requirements mentioned below in this general engineering specifications, required for proper functioning of the instruments / equipment, shall be provided / fulfilled by the bidder at no extra cost, irrespective of whether separately mentioned or not with individual instrument / equipment specifications. Further bidder shall note that in case of any discrepancy or conflict in specifications or requirements or meaning, the provisions of below general engineering specifications shall be considered governing and shall override the requirements mentioned in the detailed specifications of any particular instrument / equipment, as applicable. The general engineering specifications and practice to be followed are as under:

a) PLC / SCADA Station shall be located at Plant Control Room or as directed by engineer-in-charge providing monitoring and control facilities for entire proposed work under scope of this tender. The control room layout shall be planned after taking into consideration the space requirement of various PLC/SCADA panels, HMI, etc. It shall be properly air conditioned. Control room shall be aesthetically appealing. **PLC/SCADA system shall have spare Ethernet port with GSM/GPRS (4G/5G) or such suitable modem for third party connectivity with overall SCADA system of Client (Owner) in future or as required for monitoring complete water supply system of the city. All required register data mapping address details and other details as required for third party integration with master SCADA of Client & remote data transfer to monitor entire proposed plant at master SCADA of Client shall be provided by bidder at no extra cost**.

b) The material procured under this contract shall be offered for required factory / site inspection of client / consultant's representatives as specified elsewhere in this tender.

Factory inspection and clearance by client shall in no case relieve the bidder of his responsibilities for the correctness of operation of the offered system / equipment as per application / logic requirement.

The contractor shall submit quality / inspection plan for all major equipment including stage/final inspection as specified above for the approval in engineer-in-charge and shall follow the same.

The drawings, if any accompanying the tender documents, are indicative of scope of work and issued for tendering purposes only. These drawings indicate the general scheme for the treatment as well as the location map to enable the contractor to make an offer in line with the requirement of the Owner. Final construction shall be as per approved drawings / documents furnished by the contractor and approved by engineer-in-charge / consultant.

c) The specifications / scope of work for each item within this tender covers the design, manufacture, inspection, & testing at the manufacturer's works, proper packing for transportation for delivery at site, supply at site including transportation, loading & unloading, erection (including upgradation

work where applicable), testing, commissioning, labour etc. and also including requirement of any structural steel, fittings, piping, cables, cable trays, accessories, utilities, associated civil or mechanical works, etc., complete in all respects for proper trouble free and reliable working of instrument / item, and as required for proper operation of plant as described / intended in this tender, whether specifically mentioned or not.

d) Applicable Codes and Standards - All the equipment/item specified herein shall comply with the requirements of the latest issue of the relevant Indian & International standards. The equipment / item shall meet the requirements of requirements of Indian Standards, where available and only in cases where Indian Standards are not available, relevant International Standards shall be followed.

e) Inbuilt PID controller of instrument shall not be used for process control. Process control shall be through PLC only and necessary I/Os shall be considered for the same.

f) In outdoor unpaved areas cables shall be directly buried in ground or suitably laid as per site conditions. The cable trenches shall be sized depending upon the number and voltage grade of cables. Where underground cables cross roadways, pipe sleepers at grade, etc., they shall be protected by being drawn through PVC sleeves/ducts or suitable RCC Pipes to provide a permanent crossing. Pipes laid for mechanical protection shall be sealed at both ends.

Cables shall be laid over cable trays within the pump house and in paved areas and for cables to be laid on outdoor units.

g) Instrument installation hardware shall be supplied with each instrument whether specified or not. Generally it shall be as specified in the detailed / general specifications of instrument and as per clause “specifications of installation hardware” in this specifications, if specified or not specified elsewhere.

h) Contractor shall make provision for a separate feeder in the Plant MCC of suitable current rating to provide 230V AC $\pm$ 10%, 50 Hz $\pm$ 3Hz supply to Instrument Panel(s).

1. **GENERAL:**

The Contractor shall obtain all instruments from manufacturers of international standing.

The design and quality of all instruments shall be fully suited to the conditions which will be met in service. The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEC-801.

The instrumentation and control system shall be designed, manufactured and installed to ensure highest standard of operational reliability. Major instrumentation shall be electronic type. Panel mounted receiving instruments shall be electrically operated miniature flush mounting type unless otherwise specified. All instruments shall be installed in accordance with the recommendations or instructions of the instrument manufacturer for particular application.

All instruments shall be capable of carrying their full load currents without undue heating. They shall not be damaged by the passage of fault currents within the rating of the associated MCB or through the primaries of their corresponding instrument transformers. All instruments shall be back connected and the cases shall be earthed. Approved means shall be provided for zero adjustment of instruments without dismantling.

All voltage circuits to instruments shall be protect by DPMCB's in each unearthed phase of the circuit placed as close as practicable to the main connection.

Analogue signals shall be 4-20 mA according to BS 5862:Part I 1986 or its latest edition. They shall operate over two wires and be isolated from earth. 1-5V DC signals shall only be permitted within the main instrument enclosure.

Analogue signals shall be so connected that the failure of a remotely transmitted signal to another panel cannot affect other readings on instruments operated by the same signal.

The contractor shall furnish technical details / catalogues / drawings for the instruments and panels offered for monitoring and control of the entire plant to client/consultant for their approval prior to procurement of the same. Contractor shall offer inspection for the instruments/panel offered by him and in case of waiver of inspection by the client / consultant, necessary test certificates shall be submitted for approval of client / consultant before clearing the material for dispatch. Contractor shall submit their inspection plan to client/consultant for their approval for this purpose.

All instruments procured by the contractor as per the Engineer's approval, and those which perform similar duties shall be of uniform type and manufacture throughout the scheme in order to facilitate maintenance and the stocking of spare parts. Moving parts and contacts shall be adequately protected from the ingress of dust, and all instruments shall be protected by moisture and dust-proof cases including those mounted in panels. All equipment shall be suitable for its environment.

Panel mounted receiving instruments shall be of the electrically operated miniature flush mounting type unless otherwise stated.

Scales shall be clearly marked with black lettering and graduations on a white background. Instruments of the same type and range shall have identical scales.

Instrumentation System shall be designed as per good engineering practice.

ENCLOSURE:

All instruments enclosure mounted in the field shall be weatherproof to IP-65 / NEMA4 as a minimum.

FIELD MOUNTED INSTRUMENTS

Field mounted instruments shall, where possible, be hermetically sealed. If this is not possible, they shall be of weatherproof construction with heavy cast iron. Transmitters and similar equipment shall be further enclosed in purpose made weatherproof, glass reinforced fire-retardant polyester resin cabinets.

Particular regard shall be paid to the case of access to all instruments. Serial number/calibration plates shall be visible when the instrument is in its cabinet.

Locally mounted indicating instruments shall be mounted in viewable positions.

Field mounted instruments shall be complete with all mounting brackets, pillars, fittings and fixings to complete the installation.

FIELD TRANSMITTERS:

DP Type Flow Transmitter if used for congealing, corrosive and highly viscous services shall have Diaphragm Seal element with Capillary.

Transmitter shall be capable of delivering rated current into external load of at least 600 ohms when powered with 24V DC nominal voltage.

PUSHBUTTONS AND SWITCHES

Pushbuttons for operational circuits shall be provided with a shroud, guard or other suitable means to prevent inadvertent operation. They shall be in accordance with the high standard generally required by the specification as a whole and by the equipment with which they are associated.

Illuminated pushbuttons where used shall be of a design that allows easy replacement of the lamps from the front of the panel.

If legends are engraved on the pushbuttons they shall be clear and concise and shall be approved by the Engineer-In-Charge before manufacture.

Control switches shall be in accordance with the high standard generally required by the specification as a whole and by the equipment with which they are associated.

INSTRUMENT CONNECTIONS:

Electrical cable entry shall be ½" NPT (F). Suitable cable gland shall be used.

End connections shall meet the following unless, otherwise specified:

Threaded end connection shall be NPT as per ANSI / ASME B.1.20.1
Flanged end connection shall be as per ANSI / ASME B16.5

INSTRUMENTS:

Instruments as per following details and specifications shall be provided by vendor as a minimum. Quantities mentioned, if any, are indicative only and contractor shall provide all necessary instruments described in this section or as required for proper operation of the plant as described elsewhere in this tender or found necessary during detailed engineering in addition to below mentioned instruments and their locations. Bidder choosing to supply instrument with communication port suitable for process / diagnostic data transfer with PLC/SCADA need not consider analog signal and alarm contacts inputs to PLC.

All instruments, gauges and control equipment shall be strictly procured as per the list of approved vendors enclosed herewith as part of the tender documents

- **ON-LINE pH MEASUREMENT SYSTEM**:

The specifications in general shall be as under:

SPECIFICATIONS FOR PH ANALYZER			
A.	**GENERAL**		

1	Service		Raw / Clarified / Treated Water Application
2	Function		To measure & indicate the pH / Transmit
3	Operating Temperature	Ambient	Ambient, 50 °C Max.
		Process	40 °C Max.
4	Operating Pressure		Atm., Max. 1 Bar
5	Installation		Indoor / Outdoor under Shed
B.	**Electrodes & Electrode Holder**		
1	Type of Sensor		Combination Sensor, Digital / Smart Type
2	Measurement (Calibration) Range		As per process requirement
3	Temperature Compensation		Required, Automatic, In-built
4	Pre-amplifier		Integral or Remote as per mfr. Std.
5	**Measuring Elements:**		
a	Measuring Electrode	Material	Glass
b	Reference System	Type	Double Junction
		Electrolyte Material	Ag/AgCl with saturated KCL (Gelled Electrolyte)
		Ref. Junction / Diaphragm	Porous PTFE / Kynar / Equi. as per mfr. Std.
c	Soln. Ground Electrode		Required
		Material	Platinum / Titanium / Equi. as per Mfr. Std.
d	Sensor (Shaft) Body	MOC	Ryton (PPS) / PP as per mfr. Std.
		Type	Refillable or Completely Sealed, Non-Refillable Type as per Mfr. Std.
6	Sensitivity		$\pm$ 0.01 pH
7	Protection Class		IP-68
8	Cable Length	Integral / after connector	Min. 10m length or higher up to 100m or more as per site conditions.
9	Process Connection (Mounting)	Type	Suitable for pipe or immersion (open tank / sump) type mounting with mounting as under for both this applications:
		- For measurement on Pipe	Measurement of pH on pipe line shall be with flow through (Tee) assembly in SS304. Shall be with isolation valve & required piping up to disposal/drain
		- For measurement on Open Tank / Sump	Measurement of pH at Open Tank / Sump shall be through suitable immersion mounting assembly. Immersion assembly shall be Swivel / Pivot / Pipe Clamp Assembly suitable for hand rail mounting in SS316 or of non-corrosive material.
10	Calibration Certificate		Required
11	Buffer Solution / Powder for Sensor Calibration		Buffer Solution / Powder of near about pH 4, pH 7 and pH 9 with NIST / DIN Std. traceability or equi. standards shall be

			provided in required quantity for periodic calibration of Sensor.
C.	**TRANSMITTER**		
1	Function		Transmit and Indicate
2	No. of Inputs		Single / Dual / Multiple (up to 8 channel)
3	Transmitter Type		Microprocessor based, User Programmable, 2-Wire or 4-Wire type as per mfr. Std.
4	Location		Field Mounting
5	**pH Measurement:**		
a	pH Measurement Range		0-14 pH, programmable
b	Accuracy		± 0.25% of Measuring Value or better
c	Resolution		0.01pH
d	Repeatability		± 0.2% of Measuring Range or better
6	Temp. Compensation		Automatic & Manual
7	Output Signal		4-20 mA DC analog with HART / through suitable communication port - Profibus or Ethernet or Modbus. HART / Modbus or provided communication port of instrument to have required connectivity with PLC for instantons readings and fault diagnostics.
		Relay	Min. 2 potential free changeover contacts
8	Instrument Power Supply		100 to 240 VAC ± 10%, 50 Hz ± 5% or 24V DC as per mfr. Std.
9	Cable / Conduit Entry		1/2" NPT or M20 or equi. As per mfr. Std.
10	Local Indicator / Display		Backlit LCD Display
11	Security Access Code		Required, password protected
12	**Protection:**		
a	Elec. Area Classification		Safe
b	Enclosure	Type & Prot. Class	Weather Proof to IP-65 as a minimum
		MOC	Cast Alu. / Polycarbonate or equi. as per mfr. Std. suitable for withstanding harsh environment
13	Mounting		Wall mounting / Pipe mounting
14	Operating Temperature		0 to 55 °C
D.	**Options / Accessories:**		
1	Mounting Accessories		Required, Universal 2" Pipe and / or Wall Mounting Kit
2	Tag Plate		Required, SS 304
3	Cable Glands		Required, IP-65/66 as a min., Ni-Plated Brass / Polyamide
4	Plugs for addl. cable entries		Close up Plugs shall be provided for all unused cable entries, Ni-Plated Brass / Polyamide

5	Canopy for Analyzer / Transmitter	To prevent from direct sun and rain	Required. MOC: FRP - min. 4mm thick / G.I. - min. 2mm thick

pH readings shall be continuously displayed locally as well as at PLC HMI at control room. Low / High pH level shall be annunciated at HMI in main control room.

❖ **ON-LINE TURBIDITY METER**:

The specifications in general shall be as under:

a.	**GENERAL**		
1	Service		Raw / Clarified / Treated Water Application
2	Function		To measure & indicate the Turbidity
3	Operating Temperature	Ambient	Ambient, 50 °C Max.
		Process	40 °C Max.
4	Operating Pressure		Atm., Max. 1 Bar
5	Installation		Indoor / Outdoor under Shed
b.	**Electrodes & Electrode Holder**		
1	Type of Sensor		Nephelometric measurement, as per ISO 7027 NIR scattered light method Digital/Smart type
2a	Calibration Range		Raw Water: 0-100 NTU Normal & max. upto 1000NTU Clarified Water: 0-20 NTU Treated Water: 0-2 NTU Normal and max. upto 5 NTU
2b	Measurement Range		As per mfr. Std. suitable to measure normal turbidity range of 0-100 NTU & max. upto 1000NTU for raw water, 0-20 NTU for clarified water and 0-2 NTU)
3	Sensor Cable		Integral Cable or with water tight (IP-68) connector assembly with necessary cable
4	**Measuring Elements:**		
a	Measuring Electrode	Probe / Shaft MOC	SS 304 / PVC equi. suitable as per mfr. Std.
		Optical Window	Scratch proof / resistant Glass or Sapphire or equiv. as per mfr. Std.
5	Protection Class		IP-68
6	Cable Length	Integral / after connector	Min. 10m length or higher up to 100m or more as per site conditions.
7	Process Connection (Mounting)	Type	Suitable for pipe or immersion (open tank / sump) type mounting with mounting as under for both this applications:

		- For measurement on Pipe	Measurement of Turbidity on pipe line shall be with Flow through assembly / sensor mounting assembly Sampling pump and pipe of required size and length upto instrument / sensor and sample drain pipe back up to sump. Assembly shall be in Black color only.
		- For measurement on Open Tank / Sump	Measurement of Turbidity at Open Tank / Sump shall be through suitable immersion mounting assembly. Immersion assembly shall be Swivel / Pivot / Pipe Clamp Assembly suitable for hand rail mounting in SS316 or of non-corrosive material.
8	Mounting Accessories		Required
9	Calibration Certificate		Required
10	Sensor Calibration Kit		Required for on-site during O&M period for periodic calibration of Sensor as per manufacturer's recommendation.
c.	**TRANSMITTER**		
1	Function		Transmit and Indicate
2	No. of Inputs		Single
3	Transmitter Type		Microprocessor based, User Programmable, 2-Wire or 4-Wire type as per mfr. Std.
4	Location		Field Mounting
5	**Turbidity Measurement:**		
a	Turbidity Measurement Range		As specified above for sensor
b	Accuracy		$\pm$ 2 % of Measuring Value or better
c	Repeatability		$\pm$ 1% of measured value
6	Turbidity Calibration		Semi-Automatic, 1 or 2-point calibration or as per mfr. Std. using reference / Manual adjustment to grab sample
7	Output Signal		4-20 mA analog with HART / through suitable communication port - Profibus or Ethernet or Modbus.
8	Instrument Power Supply		100 to 240 VAC $\pm$ 10%, 50 Hz $\pm$ 5% or 24V DC as per mfr. Std.
9	Cable / Conduit Entry		1/2" NPT or M20 or equi. As per mfr. Std.
10	Local Indicator / Display		Backlit LCD Display
11	Security Access Code		Password protected
12	**Protection:**		
a	Elec. Area Classification		Safe
b	Enclosure	Type & Protection Class	Weather Proof to IP-66/67 as a minimum

		MOC	Cast Alu. / Polycarbonate or equi. as per mfr. Std. suitable for withstanding harsh environment
		Paint	Chemical Resistant / Epoxy Coating
13	Mounting		Wall mounting / Pipe mounting
d.	**Options / Accessories:**		
1	Mounting Accessories		Mounting plate (min. 3 mm thick MSEP) for complete instrument,
2	Tag Plate		Required, SS 304
3	Cable Glands		Required, IP-65/66 as a min., Ni-Plated Brass / Polyamide
4	Plugs for addl. cable entries		Close up Plugs shall be provided for all unused cable entries, Ni-Plated Brass / Polyamide
5	Canopy for Analyzer / Transmitter	To prevent from direct sun and rain	Required. MOC: FRP - min. 4mm thick / G.I. - min. 2mm thick

Turbidity readings shall be continuously displayed locally as well as at PLC HMI at control room. High Turbidity level alarm shall be annunciated at HMI in main control room.

❖ **ON-LINE RESIDUAL (FREE) CHLORINE MEASUREMENT SYSTEM**:

The specifications in general shall be as under:

SPECIFICATIONS FOR FREE CHLORINE ANALYZER			
A.	**GENERAL**		
1	Service		Raw / Clarified / Treated Water Application
2	Function		To measure & indicate the Free Chlorine / Transmit
3	Operating Temperature	Ambient	Ambient, 50 °C Max.
		Process	40 °C Max.
4	Operating Pressure		Atm., Max. 1 Bar
5	Installation		Indoor / Outdoor under Shed
B.	**Electrodes & Electrode Holder**		
1	Type of Measurement		Amperometric / Potentiostatic with pH compensation as per application, Digital/Smart Type
2	Measurement (Calibration) Range	Free Chlorine	0 - 5 mg/l free residual chlorine
3	Sample Withdrawal	As per application requirement	Peristaltic pump or suitable arrangement with necessary tubing / piping, Sample Inlet / Drain connection size as per mfr. Std.
			The withdrawn sample shall be suitably transferred back to immediate down stream or upstream process - shall not be drained /

			discharged in open. Pipe / Fitting associated or grouted with civil unit / structure shall be in GI / SS only.
4	pH sensor for compensation		Required (Refer pH analyzer specifications for sensor)
C.	**TRANSMITTER**		
1	Transmitter Type		Microprocessor based, User Programmable, 2-Wire or 4-Wire type as per mfr. Std.
2	Location		Indoor Mounting / Outdoor mounting with canopy
3	**Free Chlorine Measurement:**		
a	Free Chlorine Measurement Range		0-5 mg/l, programmable (Normal measurement range shall be 0 - 2 mg/l)
b	Accuracy		$\pm$ 2 % of Measuring Value or better
c	Resolution		0.01 mg/l
4	Output Signal		4 -20 mA analog / through suitable communication port - Profibus or Ethernet or Modbus. HART / Modbus or provided communication port of instrument to have required connectivity with PLC for instantaneous readings and fault diagnostics.
5	Instrument Power Supply		100 to 240 VAC $\pm$ 10%, 50 Hz $\pm$ 5% or 24V DC as per mfr. Std.
6	Cable / Conduit Entry		1/2" NPT or M20 or equi. As per mfr. Std.
7	Local Indicator / Display		Backlit LCD Display
8	Security Access Code		Required, password protected
9	**Protection:**		
A	Elec. Area Classification		Safe
B	Enclosure	Type & Protection Class	Weather Proof to IP-55 / 56 as a minimum
		MOC	ABS with Clear Polycarbonate Windows or equi. as per mfr. Std. suitable for withstanding harsh environment
10	Mounting		Wall mounting
D.	**Options / Accessories:**		
1	Mounting Accessories		Required, Universal 2" Pipe and / or Wall Mounting Kit
2	Tag Plate		Required, SS 304
3	Cable Glands		Required, IP-65/66 as a min., Ni-Plated Brass / Polyamide
4	Plugs for addl. cable entries		Close up Plugs shall be provided for all unused cable entries, Ni-Plated Brass / Polyamide

5	Canopy for Analyzer / Transmitter	To prevent from direct sun and rain	Required. MOC: FRP - min. 4mm thick / G.I. - min. 2mm thick
6	Strainer Kit		Required, strainer kit with required tubing & fittings for continuous operation without clogging, where applicable

Residual Chlorine readings shall be continuously displayed locally as well as at PLC HMI at control room. Low / High residual chlorine level shall be annunciated at ICP in main control room.

❖ **ULTRASONIC TX. – LEVEL / DIFF. LEVEL / FLUME FLOW**

Ultrasonic level measurement shall be accomplished by the use of non-contact, echo-time measuring equipment operating at ultra-sonic frequency. The equipment shall transmit pulses which are reflected back to the sensor from the surface of the liquid whose level is being measured.

The equipment shall consist of a sensor incorporating both transmitter and receiver, together with an integral or separate control unit. The control unit shall be microprocessor based and user programmable. Control unit shall have IP-65 protection as a minimum.

The equipment shall be provided with automatic temperature compensation, shall be suitable for operation in the designated application under the specified climatic conditions.

The sensor shall be suitable for mounting in the open, or within an enclosed tank, and shall with environmental protection to IP-67 as minimum. The sensor / transducer range shall be as required to cover Liquid Depth + Free Board + Blanking Distance as a minimum. The sensor shall be able to monitor the overflow condition of the unit and shall not get submerged in case if the unit overflows.

The control units shall incorporate:

Facilities for independently adjusting both zero and span, and shall have an output of 4-20mADC with HART proportional to selected measurement parameter of level / diff. level / flow as per user selection / program.

LCD read out of selected measurement parameter in suitable engineering units.

Secure access for parameters via a removable keypad or in-built programmer.

The overall accuracy of the level measurements shall be within 0.5 % or better of the instrument span.

The Contractor shall ensure that each part of the equipment is suitable for the application, particularly with regard to the blocking distance and transmitted beam angle or cone.

Each ultra-sonic level sensor shall be installed on a robust and rigid structure provided for the purpose under this contract. The structure shall include a means of levelling the sensor so that the transmitted beam is perpendicular to the liquid surface and shall provide a safe and easy access to the sensor for servicing and maintenance.

The contractor shall, where applicable, provide a cover / canopy around and/or above the sensor and / or the control unit them to provide a protection from direct sunlight.

- **Ultrasonic Transmitter for Level Measurement:**

Ultrasonic transmitter shall be provided to measure liquid level for all tanks/sumps. The purpose is to monitor tanks/sump levels as well as provide low level trip for safety of pumps against dry running, start/stop of pumps in auto mode through suitable logic to be decided during detailed engineering, low/high level alarm annunciation on HMI at control room, etc. The brief specifications in addition to above specifications shall be as under:

a.	**GENERAL**		
1	Application		Raw / Clarified / Treated Water Application
2	Service		Clear Water
3	Function		To measure & indicate Level / Transmit
4	Operating Temperature		Ambient 0 to 50 °C
5	Operating Pressure		Atm.
6	Installation		Indoor/ Outdoor
b.	**LEVEL TRANSMITTER / SENSOR**		
1	Measuring Principle		Ultrasonic Non-Contact type Level Measurement, Time of Flight method
2	Type		Microprocessor based, User Programmable, 4-Wire type, Remote Transmitter
3	Measurement Range		As per Process Requirement
	- Blanking Distance	Max.	0-3-0.4m max.
	- Sensor Meas. Range Selection		Sensor Range shall be Actual Meas. Range + Unit Free Board + Blanking Distance. Sensor shall be mounted above the top of sump by at least the blanking distance i.e. entire unit depth shall be measurable.
4	Temperature Compensation		Built-in, Automatic
5	Output Signal	Level	4 -20 mADC analog HART
6	Accuracy		± 0.5 % of measuring range
7	Resolution		± 3mm or suitable as per mfr. Std.
8	**Protection:**		
a	Elec. Area Classification		Safe
b	Enclosure	Type & Protection Class	Weather Proof to IP-66/68 minimum for transmitter
		MOC	Aluminium / PBT or equi. as per mfr. std.

		Paint	Chemical Resistant / Epoxy Coating
c	Sensor	MOC	PVDF or equi. as per mfr. std.
		Prot. Class	IP-68
9	Cable Length - Sensor	Remote Transmitter	Min 5 meter or higher as per site requirement
10	Process Connection (Mounting)		1.5" / 2" NPT threaded or 3" or 4" Flanged or as per mfr. Std.
11	Programmer		Built-in or Hand held type
12	Instrument Power Supply		100 to 240 VAC $\pm$ 10%, 50 Hz $\pm$ 5% or 24V DC as per mfr. Std.
13	Cable / Conduit Entry		1/2" NPT or M20 or equi. as per mfr. Std.
14	Local Indicator / Display	Level, in mm or m	LCD Display
15	Scale Graduation / Measuring Units		Engg. Units
c.	**Options / Accessories:**		
1	Tag Plate		Required, SS 304
2	Cable Glands	Protection	Required, IP-65/66 as a min.
		MOC	Ni plated Brass or Polyamide (IP-67/68 only)
3	Plugs for addl. cable entries		Close up Plugs shall be provided for all unused cable entries, SS316 / Polyamide / Equi.
4	Cabinet for Transmitter	To prevent from direct sun & rain	Required. Lockable with transparent protection cover

Level readings shall be continuously displayed locally as well as at PLC HMI at control room. Associated pumps/MOVs shall be turned on and off in automatic mode depending on the level reached using these measured levels. Low / High level shall be annunciated at HMI in control room.

- **Hydrostatic Type Level Transmitter for LOH/ROF Measurement:**

Hydrostatic type level transmitter shall be provided to monitor choking of filter bed by measuring differential water level across the filter (Loss of Head) and Flow Rate over weir at outlet of each Filter Bed (Rate of Flow) for alarm and auto / semi-auto backwash operation of filter bed as per the logic furnished by the bidder. Loss of Head and Rate of Flow shall be calculated in PLC/SCADA software and displayed at each filter console as well as at HMI at main control room.

The brief specifications in addition to above specifications shall be as under:

A.	**General**		
1	Function		To measure & transmit Level
2	Type		Hydrostatic Type
3	Service		Water

4	Max. Operating Temperature		Ambient, 50 °C Max.
5	Max. Operating Pressure		Atm./ Upto 1 Bar
6	Installation		Indoor
B.	**Transmitter /Sensor**		
1	Type		2 Wire type
2	Power Supply		24 V DC (2 wire)
3	Measurement Range, mtr		Suitable to Tank Height
4	No. of Measurement Channels		One
5	Accuracy		±0.5% of full scale
6	Out put signal	Analog	4-20 mA
7	Measuring Principle		Hydro-static Pressure Measurement
8	MOC - Body		SS-316L
9	Measuring Cell		Ceramic / as per mfr. Std.
10	Seal MOC		Viton / as per mfr. Std.
11	Protection Class		IP 68
12	Process Connection/Mounting		Mounting clamp,MOC SS 316L
13	Cable Length		As per Process requirement
14	Terminal Box/Housing		Required (IP-65 as a min)
15	Guide Pipe/Mounting Assembly		Required
C.	**Options / Accessories**		
a.	Mounting Hardware		Required
b.	Tag Plate		Required, SS 304
c.	Cable Glands		Required
d.	Canopy		Required

Level readings shall be continuously displayed at PLC HMI at control room and filter console.

- **DISPLACER OR FLOAT/BUOYANCY SWITCHES**:

a.	**GENERAL**	
1	Type	Float Type
2	Operating Temperature	0 to 50 °C
3	Max. Pressure	Atm. + Liq Depth, Max. 1 Bar
4	Specific Gravity	1.0 to 1.1
b.	**Float**	
1	MOC of Float	Polypropylene
2	Construction	Circular / Tubular / Bioconical
3	No. of Float	1
4	Protection	Min IP-68
5	Switch Type	Micro Switch, SPDT
6	Contact Rating	8A @ 230V AC (1 NO + 1 NC)
7	Cable	Inbuilt cable from Float up to Terminal Box
8	Cable Material	Suitable for Fluid application
9	Cable Length	As per SOQ
10	Process Connection	Flanged 4" NB

11	Counter Weight (Ballast)/	Required to ensure stable vertical position of the Float
	Support pipe for Clamping cable	
12	Adj. Stopper	As Applicable
13	Stopper / Ballast MOC	Rubber
c.	**Junction Box**	
1	Mounting	On Top of tank & sump, Flanged
2	Junction Box - MOC	Cast Alu.
	Prot. Class	IP-55
3	Connection Size	1/2" NPT / 3/4" ET or to suit cable dia.
4	Electrical Area Classification	Safe
5	Process Connection	Through Flange
d.	**Accessories**	
1	Cable gland	Required
2	Mounting accessories	Required
e	**Locations / Service**	Dry Run Protection of Pump (relay based logic to stop pump in any mode, auto or manual, of operation with necessary alarms.

❖ **ELECTRO MAGNETIC FLOW MEASURING SYSTEM**

Generally, the flowmeter shall be as follows:

Flow metering System

Each flow metering system shall consist of the primary transducer (Sealed to IP-67 for above ground / non-submerged application and IP-68 for below ground within chamber for submerged application), earthing rings, the necessary signal converter and power supply unit and all cabling between the primary transducer and signal converter and power supply unit. Flowmeter in general shall be sized considering maximum design line velocity as specified in this tender specifications (2.5m/sec for pumped flow) except for all sludge flowmeters which shall be of minimum 80mm size or higher as required as per sizing calculations.

Each of the signal converts / power supply units shall be supplied for remote mounting, unless otherwise specified.

The signal converts / power supply units shall be provided with a 4-20 mA output signal, linear with flow and suitable for retransmission to remote instrumentation. The above units shall operate from a 240V 50 Hz supply.. The supply voltage may vary by $\pm$ 15% and frequency between 47 and 53 Hz.

The contractor shall provide sufficient suitable cable to allow for the primary transducers to be situated up to 10 meters from their signal converters, unless a longer length is specified.

The Contractor shall provide full details of the cable, he proposes to use.

The general specifications for electromagnetic flow meter shall be as under:

Service		Water / Sludge / Chemical Application
Function		To measure & indicate Instantaneous Flow and Totalized Flow / Transmit (Flow)

Fluid Conductivity		> 20 µS/cm
Installation		Indoor or Outdoor, Below or Above Ground as per piping / site conditions
Flow Sensor / Tube / Element		
Type of Sensor		Full Bore type
Flange Materials		MS / CS Epoxy Painted or Better
Tube Material		SS304 or better
Liner Material		Clear Water Application: Hard Rubber / PU / Ebonite Rubber Chemicals/Alum Application: PTFE
Body Material / Coil Housing		MS Epoxy Painted or cast alu. with corrosion resistant paint of better as per mfr std.
Electrode Material		Clear Water Application : SS316L/Ha-C Chemicals/Alum Application: Ha-C
Power Supply		From Transmitter
Grounding	Type / Material	Metallic Line: Earth Electrode / Set of Earth Rings Non Metallic Pipe: Set of Earth Rings Only / SS316
Protection Class	Above GL or Indoor within Pump House / Bldg.	IP-67 for flowmeters installed above Ground Level or if installed indoor within pump house / building above ground level.
	Below GL / outdoor	IP-68 for flowmeters installed outdoor / below Ground Level (shall be mounted within RCC Chamber with water proof plaster)
Cable Entry (for separated / remote version) & Glands		Shall be as per mfr. Std. and suitable to maintain the specified protection class at site
Cable Length	Sensor to Transmitter	Min. 10m, dual shielded cable
Painting, where applicable	CS / other	Chemical Resistant, Epoxy Painted
TRANSMITTER		
Function		Transmit and Indicate
Type		For Outdoor / Below ground Sensor, Tx. shall be Remote (Non-Integral) type, Microprocessor based, User Programmable, 2-Wire or 4-Wire type as per mfr. Std.
		For Within Building or Pump House above ground level Sensor , Tx. shall be Remote / Integral type Microprocessor based, User Programmable, 2-Wire or 4-Wire type as per mfr. Std
Flow / Velocity Measurement Range	Max. Flow Velocity	Flowmeter shall be capable to measure flow with velocity up to max. 10 m/sec.

	Velocity for Sizing	Flowmeters for clear water shall be sized to measure flow with max. flow velocity up to 2.5m/sec. or as per specified size in scope of work / specifications Meter size for backwash tank outlet flow shall be same as matching to pipe size.
	Minimum Flow Velocity	up to 0.3 m/sec. (shall measure flow without loss of accuracy up to 0.5 m/sec and below that, accuracy shall be as per mfr. Std.)
Accuracy	Flow Vel. >= 0.5 m/s	± 0.5% of Flow Rate / Measured Value or better
	Flow Vel. < 0.5 m/s	as per mfr. Std. for flow velocity up to 0.5 m/s
Output Signal	For Flow	Modbus RS-485
Instrument Power Supply		100 to 240 VAC ± 10%, 50 Hz ± 5% or 24V DC as per mfr. Std.
Cable / Conduit Entry		1/2" NPT.
Local Indicator / Display	Inst. & Total Flow	Backlit LCD Display for Inst. & Tot. Flow readings
Enclosure	Type & Protection Class	Weather Proof to IP-65 as a minimum or better
	MOC	Cast Alu. or equi. as per mfr. Std. suitable for withstanding harsh environment with chemical resistant / epoxy coating
	Type	Wall mounting / Pipe mounting
Vibration Conditions		Conformity with IEC 60068-2-6 or equi., shall be able to endure vibration, when in service, without any degradation in performance
Pipe not Full Detection / Empty Pipe Detection		Required
Canopy for Transmitter	To prevent from direct sun and rain	Required. MOC: FRP - min. 4mm thick / G.I. - min. 2mm thick
Expansion Bellows	SS 304	Required at suitable location to enable ease of removal / insertion of flow meter for maintenance

Flow (Instantaneous and Totalized) readings shall be continuously displayed at PLC HMI.

Flow meter shall be mounted above ground level / HFL as far as possible. In case of flowmeter mounted below ground level / HFL shall be provided with suitable water proof chamber constructed in RCC elevated sufficiently above GL of sufficient size for ease of operation and maintenance as decided during detailed engineering.

Flowmeter shall be mounted as per manufacturer's recommendation and good engineering practices and each flow meter shall be provided with a bellows at suitable location to enable ease of removal / insertion of flowmeter for maintenance. For flowmeter mounted below ground level, chamber shall be sized suitably to accommodate flowmeter and bellows in the same chamber.

❖ **PRESSURE GAUGES**:

All pumps, compressors and air blowers shall have PG at their discharge lines. Pressure Gauges for process fluids containing sludge/solids and corrosive chemicals shall be of diaphragm type.

PG dial face shall be marked with pressure element material. Ranges shall be so specified that the gauge normally operates in the middle third of the scale and shall confirm to IS-3624 standard dials, wherever possible.

Diaphragm seals, filled type or mechanical type shall be furnished where plugging of the element may occur or where suitable material is not available in highly corrosive services. When chemical seals are required, they shall be of clean out type with flushing connection.

Pressure Gauge Dial Size shall be of minimum 150mm and of white with black engraving, shall be provided with blow out disc, toughened/safety glass window, bayonet type bezel ring, case material of SS304, Bourdon Element / Socket of SS316, movement parts of SS, weather proof to IP-65, offering accuracy of $\pm$1% of FSD. Micro-zero adjustment at the pointer, bottom process connection shall be 1/2" NPT, over-range protection of 130% of FSD.

In case of Diaphragm type Pressure Gauge, Diaphragm / Lower Chamber Wetted Parts shall be os SS316, Upper Chamber of SS304 / SS316, with silicon oil sealing fluid, 2" ANSI B16.5 flanged process connection

Following accessories shall be supplied as a standard with all pressure gauges:

Syphon / MOC	:	Required,SS316,for process temp.range exceeding 60°C
Snubber / MOC	:	Required, SS316, for pulsating flow/output application (blower/compressor/dosing pump delivery, etc.)
Glycerin Filled	:	All pump delivery
Isolation Valve	:	Required, Gate / Ball Valve, SS 316
2-Valve/3-Way Manifold	:	Required, SS 316

❖ **PRESSURE TRANSMITTER**

Pressure readings shall be continuously displayed at PLC HMI with low and high pressure alarm annunciation at HMI. The transmitter specifications shall be as under:

Transmitters shall be manufactured from material suitable for use with the process medium and for the site ambient conditions.

a.	**GENERAL**		

1	Type of Measurement		Gauge Pressure
2	Service		Raw / Clarified / Treated Water /Air Application
3	Function		Transmit & Indicate
4	Type		Smart
5	Mounting		Yoke
6	Zero elevation & suppression		Provided
7	Operating Temperature		Ambient, 0 to 50 °C
8	Installation		Indoor / Outdoor
b.	**Measuring Unit**		
1	Element Type		Diaphragm
2	Element Material		SS316L
3	Body Material	MOC	Cast Alu. or equi. as per mfr. Std.
4	Over range Protection		130% of maximum static pressure
5	Process Connection		1/2" NPTF through adaptor
6	Connection Location		Bottom
7	Calibration Certificate		Required
c.	**Transmitter**		
1	Type		Microprocessor based, User Programmable, 2-Wire, Smart
2	Measurement (Calibration) Range		As per Process Requirement:
3	Accuracy		± 0.1% of Span
4	Output		4-20 mADC , Two Wire, with HART protocol
	- Load Resistance		600 Ohms max.
5	Tx. Power Supply		24V DC
6	Cable Entry		1/2" NPT F
7	Local Indicator / Display		Digital Display
8	Scale Graduation / Measuring Units		Engg. Units
9	**Protection:**		
a	Elec. Area Classification		Safe
b	Intrinsically Safe		N.A.
c	Enclosure	Type & Protection Class	IP-66/68
		MOC	Cast Alu. or equi. as per mfr. Std. suitable for withstanding harsh environment
		Paint	Chemical Resistant / Epoxy Coating
		Requirement for	N.A.

		Hazardous Area	
10	Mounting		2" Pipe Mounting / Field Enclosure Mounting
d.	**Options / Accessories:**		
1	Mounting Accessories		Required, 2" Pipe Mounting
2	Tag Plate		Required, SS 304
3	Cable Glands		Required, IP-65/66 as a min., Ni-Plated Brass / Polyamide
4	Plugs for addl. cable entries		Close up Plugs shall be provided for all unused cable entries, Ni-Plated Brass / Polyamide
5	Isolation Valve		Required, ½" Ball Valve
6	3-Way Manifold (2 Valve)		Required (With SS-316 Tubing/fitting as required)

❖ PROGRAMMABLE LOGIC CONTROLLERS (PLC) PANEL

PLC & AUTOMATION REQUIREMENT FOR WTP

The vendor shall provide main Instrument Control Panel (ICP) located at control room at administration building and Local Control Panel / Filter Consoles (LCP) at Filter House Gallery for local monitoring and control of filter beds. Local Control Panels shall also be provided at PMCC/MCC Rooms, and other locations if necessary as per contractor's design. The PLC systems shall be centralized configuration or with Distributed I/O or remote PLC configuration integrated over suitable communication network.

All filter beds shall be possible to be backwashed automatically through PLC with complete back wash cycle programmed in the PLC as per process requirement. Auto backwash shall be started with suitable interlocks of LOH/ROF controller or through Selector Switch at filter console or through soft PB at HMI, as per the mode selection.

It should be possible to operate/control and monitor status of all electric drives, electrically / pneumatically operated valves, process parameters (level, diff/ level / flow / LOH & ROF / water quality analyzers, etc.) of plant at main control room PLC HMI. Valves shall be monitored for full open, intermediate and full close position and electrical drives for motor on, off and trip status. Separate indication at HMI, Red indication for Valve close / motor off status, Green indication for Valve open / motor on status and Amber indication for Trip shall be provided.

Filter console panel (FCP/LCP) shall be provided one no. between three beds. Filter Console Panel shall be provided with min. 10" color touch screen HMI and it shall be possible to operate/monitor electrically operated valves for filter beds associated to that particular panel and also operate/monitor any of the air blowers & backwash pumps for backwash operation. Operation and monitoring of valve/blower/back wash pump shall be provided at LCP. Valves shall be monitored for full open and full close position and electrical drives for motor on, off and trip status. Backwash tank / sump level and LOH/ROF indication of associated bed shall be displayed at each Filter Console. It shall be possible to operate the electrically operated valves, air blowers & backwash pumps both, from control room (through HMI/SCADA) as well as locally at filter beds from filter consoles (through local HMI) as well as in full auto mode without any manual intervention in

LOH/ROF initiated auto backwash cycle and as per operator selection of each mode at SCADA. It is to be noted that all the I/Os of a particular bed (especially valves and LOH/ROF) be wired in the FCP associated to that bed only. Necessary operation mode selector switches shall also be provided at HMI/SCADA to enable operator select the mode of operation i.e. in full auto mode or to operate from filter console (default mode) or from SCADA/HMI or in manual mode, separate for each type of equipment / set of filter bed valves and shall have required interlocks and level / timer / LOH-ROF or such process interlock based auto operation when selected in full auto mode. All electric drives shall be possible to operate manually from MCC/LCP and actuator through actuator mounted push buttons in manual mode.

1. **POWER SUPPLY TO PACKAGE:**

A) Power Supply shall be made available by the bidder at the following voltage levels, **unless otherwise specified**.

- For Instruments, Control Systems, Analyzers : 230V AC $\pm$ 10%, 50 Hz $\pm$ 3 Hz/ 24 V DC
- Solenoid Valves, Relays, Lamps : 24V DC
- Input Interrogation Voltage : 24V DC
- Panel/Cabinets Lighting : 230V AC $\pm$ 10%

24V DC required for Input Interrogation, relays and lamps etc., same shall be generated by the bidder using **dual redundant power supply**. Power shall be suitably conditioned by providing on-line type UPS (with in-build AVR) to prevent damage to instruments against power fluctuation / disturbances.

B) Instrument power circuits shall be individually protected from fault with the help of Dual pole Miniature circuit breakers (DPMCB's). Power supply to the individual instrument shall be disconnected with the help of (DPMCB's).

2. **EARTHING:**

Vendor shall provide separate earth bus bar connections for shield and panel electrical earthing.

Any special earthing requirements, if required, shall be provided by vendor during detailed engineering.

Necessary earth pits shall be provided for the same by the vendor.

3. **INTERLOCKS / LOOPS:**

All plant interlocks shall be carried out using PLC to be supplied by vendor for fail safe and reliable operation. Vendor to indicate all process interlock requirements on the P&IDs.

Loop integrity must be maintained for each loop. No component of any loop shall be shared by other loop.

The system shall be designed fail safe and shall meet the following requirements, as a minimum:-

a) All initiating contacts shall be close under normal conditions and shall open under abnormal conditions.
b) All relays and solenoid valves shall be energised under normal conditions and shall de-energise under abnormal conditions.

The system shall be designed using PLC unless specified otherwise and shall be located locally or remotely as per the operational requirements. The system shall meet the following requirements as a minimum:

a) The electromagnetic relays shall be low power continuously rated type and shall have LED for status indication.
b) The relays shall be plug-in type and their plug-in bases shall have screwed terminals for interconnection. Lug type soldered connection shall not be acceptable.
c) Each relay shall have two numbers of 'NO' and two numbers of 'NC' contacts as a minimum each suitable to drive the connected. Out of these, one 'NO' and one 'NC' contacts shall not be used.

4. **CONTROL PANEL:**

Control panels shall be prefabricated type, Sourced from Approved Vendors.

Control Panel shall be CNC machine prefabricated out of CRCA sheet steel of thickness not less than 1.5 mm, modular in construction, properly reinforced, powder coated and having rigid frame structure. Internal mounting plate including the gland plate shall be 3 mm thick. Anti-vibration pad, Predrilled base channel ISMC – 100 or equivalent for all sides. The instrument panel shall have dimensions as per system requirement.

The exterior corners and edges shall be rounded to give a smooth overall appearance with projections kept to a minimum.

Lifting lugs shall be provided for installation purposes and shall be replaced with corrosion resistant bolts after installation.

Control Panel shall be completely metal enclosed and shall be dust, moisture and vermin proof. Panel enclosures shall provide a degree of protection not less than IP 52 in accordance with IS: 13947 Part-I.

Control Panel shall be freestanding type. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation.

Metal sills in the form of metal channels properly drilled shall be furnished along with anchor bolts and necessary hardware for mounting the Instrument panels. These shall be dispatched in advance so that they may be installed and leveled when concrete foundations are poured.

Cable entries to the panels shall be from the bottom with fire retardant spray compound sealing. Instrument panels shall be provided with louvers along with washable micron filters AIRIN – AIROUT fans will be provided.

No process fluid of any kind, except instrument air, shall enter the instrument cubicle. All cable entry shall be from the bottom of the panel. Also power supplies greater than 230 V shall not enter the ICP/LCP.

The internal layout of the panel/cabinets shall be designed considering proper approach for each item for maintenance. Following point must be taken into consideration while deciding the internal layout:

a.) All wiring inside the panels shall be housed in covered non-flammable plastic raceways arranged to permit easy accessibility to various instruments for maintenance adjustment, repair and removal. No raceway shall be more than 70% full.
b.) Separate wiring raceways shall be used for power supply wiring, DC and low level signal wiring.
c.) Distance between terminal strips and side of the panel parallel to the strips up to 50 terminals: Min. 50 mm.
d.) Distance between terminal strip and top and bottom of cabinet: Min. 75 mm.
e.) Distance between two adjacent terminal strips: Min. 100 mm.
f.) Distance between cable gland plate and the bottom of strips: Min. 300 mm.
g.) 20% spare terminals shall be provided as a minimum.

Overall height of Control Panel shall not exceed 2100 mm. Panel mounted instruments and controls shall be such mounted that they are accommodated between 800 mm and 1300 mm from floor level.

Control Panel shall be provided with fluorescent type lighting fixtures controlled from totally enclosed door operated switches for internal illumination of the panel cabinets.

Contractor shall provide with necessary cooling fans and cut-outs covered with appropriate filters for necessary air changes to limit temperature rise within panel to 5 deg. C over ambient temperature.

For cases where PLC is to be mounted, panel shall be designed suitably as per PLC manufacturer's recommendation. Necessary marshalling boxes may be considered if required as per design.

Control rooms (PLC/SCADA Control room at Plant) shall be provided with air conditioners of sufficient numbers/quantities as recommended by Air conditioner manufacturer based on room size, heat load, etc. However, a minimum of 2 nos. 1.5TR capacity air conditioner shall be provided.

Windows in control room shall be provided with suitable louvers to prevent direct heat / glare.

Mounting
All equipment's on front of panel shall be mounted flush or semi-flush. In case of semi-flush mounting, only flange or bezel shall be visible from the front.

Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment.

Equipment mounted inside the panel shall be so located that terminals and adjacent devices are readily accessible without the use of special tools. Terminal markings shall be clearly visible.

Earthing for Instruments
The panel shall be equipped with an earth bus securely fixed along the inside base of panel.

Minimum two numbers of Dedicated Earth Stations to be provided each for Instruments / Panel Earthing and for Signal (Electronic) earthing. The earth station shall be of cu plate type electrode

(Size Min. 600 X 600 X 3.15 mm thick) or maintenance free pipe in pipe technology having earth electrode of 50 mm dia. and length of 3000 mm.

All metallic cases of instruments and other panel mounted equipment shall be connected to the instrument earth bus. The minimum section of the earth bar shall be 25 mm x 3 mm.

Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken shall not be permitted. However, looping of earth connections between equipment to create alternative paths to earth bus shall be provided.

A separate instrument earth bus will be created which will be floating and all the cable shields will be terminated onto this bus. This bus will be connected to an electronic earth pit as specified above.

Space Heater
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 V AC. 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.

Interior Lighting and Receptacles
Each panel shall be provided with either a LED lighting fixture rated for 5 watt, 230V, 1 phase, 50 Hz supply for the interior illumination of the panel during maintenance. The illumination lamp shall be operated by door switch or manual switch. Each panel section shall be provided with separate lighting.

Each panel shall be provided with 230V, 1 phase, 50 Hz, combined 5 amps and 15 amps, 3 pin receptacle with a switch and neon indication. The receptacle with switch shall be mounted inside the panel at a convenient location. If the panel has front and rear doors then maintenance socket shall be provided at both locations.

Labels
All the equipment mounted on the front facia of Instrument 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.

Switches and Miniature Circuit Breakers (MCBs)
Each instrument panel shall be provided with necessary arrangement for receiving, distributing, isolating and protecting of DC and AC supplies for various controls, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with DP Miniature Circuit Breakers (MCBs).

Intra-panel (i.e. Panel Internal) Wiring
Connections within a panel, between panel mounted devices and terminal blocks or between two panels mounted devices will be made by 600 volt grade, multi stranded copper flexible conductor insulated with FRLS Grade PVC and designed for a minimum conductor temperature of 70 degrees centigrade. The wires shall be shielded, where necessary.

Panels shall be supplied completely wired internally, with a colour coding scheme decided mutually between the Purchaser and the Contractor, 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. Internal wiring or wiring between the two assemblies shall be commensurate with mechanical safety.

Terminal Blocks
Terminal blocks for power connection shall be 600V grade, 20 amps rated, one-piece moulded. All control output terminals will be fused type and all other input signal terminals will be clip on shrouded type.

All spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks.

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, these wires shall not be terminated on adjacent terminal blocks.

Cable Supports
All external cables shall present a neat appearance and shall be suitably braced, placed in troughing clipped or laced to prevent effects of vibration.

Terminal / Identification
Every terminal plug shall be uniquely identified within the terminal cabinet by means of a terminal number. Appropriate labels shall be used to permit quick and unambiguous identification of each terminal and test plug.

Painting of System Cabinet/ Control Desk
All sheet steelwork shall be painted using seven tank processe in accordance with the following procedure:

i. The pretreatment shall be hot process with running water for rinsing.

ii. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.

iii. Rust and scale shall be removed by trickling with clean water followed by final rinsing with dilute dichromate solution.

iv. The control panel shall be powder coated. Thickness of coating shall be around 60 microns. QA test certificate shall be furnished for thickness adhesion and hardening of powder coating.

5. **ALARM ANNUNCIATOR:**

(i) Microprocessor based alarm annunciators shall be provided, **if specified in detailed specifications for instruments**, for generating audiovisual alarms for each abnormal condition. Alarms shall be initiated by the opening and closing of volt-free contacts which shall remain unchanged throughout the periods in which the alarm conditions exist. Alarm circuits

shall be capable of conversion from open-healthy to open-alarm or vice versa by a simple modification after installation requiring no additional parts or special equipment. Each alarm shall initiate the operation of both visual and audible devices. The sound intensity of each audible device shall be suitable for the maximum sound level of its environment. The sequence of alarm should be user selectable by dip switch.

(ii) 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.

(iii) Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds do not initiate any action.

(iv) Isolation facilities shall be provided for the hooter using an MCB

(v) Alarm annunciator/indicator legends or labels shall be arranged with three lines of text as follows :

i.	top line	:	location	
ii,	middle line		:	parameter
iii.	bottom line		:	status

e.g. RESERVOIR
LEVEL
HIGH

The annunciator will be split / integral architecture type and the facia will have Super Bright LEDs.

Alarm annunciator shall be provided on instrument control panel for annunciation of alarms in control room. A minimum of 20% spare windows with alarm modules shall be provided in alarm annunciator.

The technical particulars of alarm annunciator are as follows:

(a) Technical Particulars

i.	Type	:	Microprocessor based, split type / integral type with alarm windows mounted on the front door and electronic modules inside the panel
ii.	Mounting	:	Flush with panel
iii.	Construction	:	Modular
iv.	Inputs	:	Potential free, NO/NC contacts
v.	Size of windows	:	60 mm X 26 mm
vi.	Operating sequences	:	First up (user selectable dip switch)
vii.	Bulbs per channel	:	2 (Cluster LEDs)

viii.	Push Buttons	:	For Reset, Accept and Test
ix	Hooter	:	Required, electronic type
x	Power supply	:	24 V DC/240 V AC
xi.	Power supply status	:	Required indication
xii	Weather protection	:	IP-52 of IS 13947
xiii	No. of Windows	:	as per requirement + 20% spare windows

In case if hard wired annunciator is not specified in detailed specifications for instruments, then visual alarm at HMI and audio alarm through panel mounted hooter along with rest push button shall be provided for all the required alarms as per specifications / approved P&ID / process requirement.

6. RECEIVING INDICATORS MOUNTED AT ICP/LCP:

All indicators/controllers shall be electronic (microprocessor based) type programmable indicator and shall be mounted on the control panel located in the control room. Multiplying factors, shall be specified on manufacturer's nameplate, if applicable. Specifications, as applicable are as follows:

Process Indicator:

Type	:	Microprocessor based, programmable
Input	:	4-20 mA
Display	:	4 ½ Digit, 7 Segment LED display
Display Units	:	% or Engg. Units, user programmable at site
Alarm Set point	:	Two nos., pot. free relay contact rated at 5A @230V AC resistive load, adj. over entire range
Transmitter Supply	:	Required, 24V DC @30mA
Retransmission Output	:	Required, 4-20 mA in 600 ohm load
Accuracy	:	$\pm$ 0.25% of FSD
Terminals	:	suitable for up to 2.5 sq.mm. wires
Mounting	:	panel flush mounting
Power	:	110/230 V AC, 50 Hz

Flow Indicator cum totaliser shall also have following in addition to above:

Totalizing Counts/Hr	:	User Programmable at site
Totaliser Display	:	6/8 Digit Digital Display with Battery Backup to retain totalized data in the event of power failure for a minimum period of 24 hours.

Notes :

Indicating instruments shall indicate various process parameters as per following measuring units, in general :

Flow	M^3/Hr or MLD or LPS	as per process requirement
Level	m	Meters
Pressure	Mt. head of water or Kg/Cm^2	as pr process req.
Temperature	C	Degree Celsius
Concentration	ppm or mg/l	Parts per million or

		Milligram per litre.
Current	A	Amperes
Voltage	V	Volts
Power	W	Watts
Electrical Energy	Whr	Watt-hours
Frequency	Hz	Hertz
Speed	r.p.m.	Revolutions per minute.

7. **PROGRAMMABLE LOGIC CONTROLLERS**

These specifications shall be read in conjunction with control panels (ICP & LCPs / filter consoles) and other PLC/Panel/Automation/Major Logic requirements specified above of thes instrument specifications and other requirement specified in scope of work, process description & specifications and elsewhere in tender specifications.

Codes and Standards

PLC shall comply with International standards such as NEMA, IEC, ANSI, ISA, IEEE, DIN and VDE

DESIGN AND CONSTRUCTION REQUIREMENTS

PLC H/W & S/W shall be from the same family and should be sourced from approved Vendors only.

Programmable logic controller (PLC) shall be microprocessor based with 32 bit processor and be fully programmable and capable of performing control relay logic, including timing, counting, sequencing, and interlocking.

The PLC shall be high performance processors suitable for real time process application. High inherent reliability, self-checking, error-recovery and trouble-shooting features shall be some of the features of PLC.

The PLC shall have a modular / modular chassis design which allows for ease of future expansion. The processor module shall be easily removed from the I/O chassis for service or repair. The I/O chassis shall have slots for installing I/O cards, communications, or other special function modules. All I/O cards and modules shall be capable of being installed in any open slot in the chassis or DIN rail mounted. Module and channel level diagnostics should be standard feature.

The PLC shall have a suitable power supply and can be easily serviced or replaceable. The system shall be capable of being powered on 120VAC / 230VAC / 24V DC as per mfr. Std.

The PLC shall be rated to operate from 0 to 60 Degrees C, with a humidity rating of 5 to 95% (non-condensing). All module circuit boards shall be encased and protected such that, when properly installed, they are not exposed to accidental contact by personnel or other objects.

Bidder to note the location specific requirements specified as under to be provided/included in scope of work irrespective of whether mentioned in following general specifications or not:

PLC Based Instrument control Panel at **WTP** with Local SCADA system comprising of min. 1 nos. 24" LED PC console for EWS cum OWS, 1 no. A4 size Laser Jet Printer cum scanner cum xerox for report generation and alarm , Online UPS with min. 60 min backup, Additionally for remote

data transmission facility 4G/5G GPRS connectivity shall be provided to transmit data of entire WTP Site to be monitored at central SCADA / Office of Client.

Note: The cost of acquiring SIM card and it's renewal / operating cost up to completion of O&M period shall also be in bidder's scope.

The SCADA system at WTP site shall comprise of following as a minimum:

- 1 Nos. Desktop PC for EWS cum OWS with 32" Full HD LED,
- SCADA software licence with min 25 display / Equivalent Screen Runtime License
- 1 Nos. A4 Laser printer cum scanner cum xerox for report & alarm printing respectively.
- Reporting Software
- Online UPS with minimum 60 minute backup
- Required Licensed OS (Operating System), Anti-Virus & other software
- 4G/5G GPRS Modem with SIM CARD for Remote Data transmission to Central SCADA of client
- Console furniture for PC and Printer
- Any other as required to complete the work in all respects

For GPRS connectivity the bidder shall select service provider after checking the feasibility and signal strength in the area of coverage of this contract and obtain prior approval from Client Engineer.

Basic Processor Functions

Real-time control of output points for turning on and off digital devices such as motor starters and solenoids.
Read the status of real world digital inputs from limit switches, float switches, and other field devices.
Real-time control of analog process control variables.
Read the status of real world analog set points and feedback values.
Perform timing, counting, sequencing, and interlocking functions for pump/equipment control.
Process local alarm handling functions

Math and Advanced Functions
Four function math in floating point or signed integer format
Convert to/from BCD
Data comparison and manipulation
Scaling from integer data into engineering units such as flow, level and pressure
Full PID Instructions for control of process control variables such as flow, level and pressure.
ASCII instruction set for interfacing to ASCII devices
Compute Instruction which executes a mathematical expression and can be used for totalizing functions
Trigonometric and Exponential math functions
Real-Time Calendar Clock for time stamping alarms and events.

Automatic restart of the system on resumption of power shall be provided.

The processor shall have solid state RAM memory to store the application program, process data, and alarm status. This memory shall have both capacitor and battery backup in the event that input

power to the processor is lost. It shall also have the capability of EEPROM backup which automatically reloads the memory on a power cycle. The processor shall have the ability to automatically control the process on a power cycle, provided there are no major or unrecoverable processor faults.

Processor RAM memory shall be adequate and selected with at least 25-30% spare capacity for application program storage over the actual requirement, and also should be expandable for future expansions. Bidder shall demonstrate the spare capacity at the time of commissioning and after completion of entire logic development for the plant controls and monitoring as per the logic write-up to be furnished by client / consultant to the successful bidder after award of work.

Sufficient program memory and data memory space shall be provided. System initialization and application software shall be stored in EEPROM or EPROM with necessary hardware. Running data shall be stored in a RAM with internal battery back-up

All process parameters and electrical parameters shall be monitored at HMI and necessary controls actions shall be initiated.

All PLC/HMI products shall be fully supported and available for purchase for up to ten (10) years from the date of the original system purchase and shall be upgraded or maintained as required till completion period of O & M contract, at no extra cost and accordingly any software or hardware getting obsolete shall be upgraded or replaced by contractor at no extra cost with prevailing latest version during this period.

The PLC & SCADA System shall be provided either by PLC OEM or Authorized System integrator of PLC OEM only. In case of system integrator, required valid certificate from OEM shall be provided in this regards along with drawing / document submission.

Specific Requirements for PLC

(a)	Expandability in future	:	30% of installed I/O capacity as per present requirement at each location
(b)	Weather Protection	:	IP-20 for PLC hardware and shall be IP-54 of IS 13947 when mounted in ICP
(c)	Power Supply	:	230V AC / 24V DC
(d)	Interrogation Voltage	:	24V DC
(e)	CPU, communication module and power supply module	:	Required, high performance 32 bit CPU Module having modular configuration suitable for real time process application. CPU shall be preferably of same family if provided at different locations. For filter consoles 16 bit CPU / micro PLC is acceptable.
(f)	Scan time	:	0.5 Milliseconds or better for 1K instructions
(g)	Key Switch for Processor	:	Shall be as per mfr. Std.
(h)	Mounting	:	Inside the main instrument/local instrument control panel
(i)	I/O Capacity of CPU	:	30% expandability in future over present I/O requirement (actual + spare I/O)
(j)	Inputs and Outputs	:	As required for process operation with an intention to maximize the automatic operation of

			equipment/plant and ease of operation and maintenance of the plant.
(k)	System Loading	:	Max. 60% under worst loading conditions
(m)	Power supply to sensor / transmitters	:	Required
(n)	Type of input	:	NO/NC – Contacts field selectable from programmer
(o)	Outputs	:	Relay outputs for driving MCC starter coils, driving motorized valves etc.
(p)	Spare I/O (Wired)	:	Min. 2 nos. or 10% of each type of I/O, whichever is higher, at each panel/location, wired to terminal block
(q)	Accessories	:	SCADA Runtime and Reporting Software
(r)	Interposing Relays	:	Shall be provided for all the Digital Output (DO) including spare DO & for Digital Input where ever required
(s)	Interface (Hardware and Software) to SCADA	:	Required (plug and play) ready to use type
(t)	Printers for alarm, status, report generation	:	1 No., A4 size Laser Jet Printer cum Scanner cum Xerox required at control room
(u)	Computer –For EWS cum OWS	:	Desktop / Workstation grade PC with min. 32" Full HD LED monitor having following specifications as a min.: Intel core i7 CPU or better, / 16 GB DDR4 RAM / 1TB SATA HDD / PS/2 Keyboard / Scroll Mouse / 2 USB 2.0, 1 standard serial port, 1 parallel port, etc. / Licensed OS (Windows 10 or latest version) and supported by SCADA software / licensed version of anti-virus software package.
(v)	Type of Protocol on communication port	:	Standard Min. 10/100 MBPS speed for SCADA and 12MBPS speed or suitable for Distributed I/O. The data communication shall be based on GSM/GPRS with required communication port and modem suitable for GPRS data communication on 4G network of selected service provider.
(w)	Tests	:	Functional test (simulated) for complete system Test for monitoring function Voltage variation test (at ±10% of rated voltage. Factory acceptance test (to be witnessed by Purchaser / purchaser's representative Simulation test for all logic / loops (to be witnessed by Purchasers / purchaser's representative Vendor to submit all Test Certificates for purchaser / consultant's review.

Input / Output Modules

(a) Standard DIN Rail / rack mounted I/O modules with plug-in cards shall be provided. Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with preferably pre-fabricated cables and plug in card type connectors.

(b) Min. 2 nos. or 10% of each type of I/O, whichever is higher, extra I/O's of installed capacity for each type at each location 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 of the installed capacity.

(c) Discrete Input Cards: Solid-state input circuits rated for 10-30VDC operation. Cards must be available in 8 or 16 or 32 point configurations and shall source current to the field device. Each input point shall have a status LED which indicates the ON or CLOSED condition for that field sensor or switch.

(d) Discrete Output Cards: Solid-state output circuits rated for 24VDC operation. Cards must be available in 8 or 16 or 32 point configurations and shall be able to operate a control relay. Each output point shall have a status LED which indicates the ON condition of the output. Cards must have removable terminal strips so that module can be easily replaced without disturbing the field wiring. The control Relay-contact shall be rated for 5A @240VAC or 5A @125VDC. The control relay shall have a LED indication to show the status of the control relay.

(e) Analog Input Cards: Analog inputs shall capable of reading in 0 to 20mA or 4 to 20mA signal. The A/D converter shall provide a minimum 12 bit resolution over the full range from module minimum to module maximum.

(f). Analog Output Cards: Analog Outputs shall be capable of outputting 0 to 20mA or 4 to 20mA signals. The A/D converter shall provide a minimum 12 bit resolution over the full range from module minimum to module maximum.

(g) All cards shall have optical isolation between digital and field side circuitry.

(h) Some of the common features of the I/O modules shall be as follows:

1) Filters for noise rejection.
2) Surges withstand facility as per standards.
3) All the modules shall be of addressable type.

Communications

(a) PLC shall be with Minimum one port for High performance Ethernet communication at 10/100 Mbps network for program upload / download, on-line editing, peer- to –peer messaging, data acquisition and man machine interface.

Shall be open protocol for connectivity and communication with third party hardware/PLC/SCADA in future (for monitoring at central control room of client in future). The PLC/SCADA system shall provide connectivity (through Ethernet/equi. Communication port) for remote connectivity and data transmission requirement by client as required. Ethernet switch or such required hardware/software shall be provided for this purpose for ready to use connectivity in future. Required register data shall also be provided

by contractor / vendor for remote data transmission & acquisition, storage and display of parameters at remote site.

(b) PLC shall be with minimum One RS 232C/RS485 port (with Modbus protocol) for connecting devices over network for data acquisition from Energy analyzers/soft starters /VFDs /temp. scanners/instruments/Modbus based equipment & valves/gates, etc.

(c) Any other communication ports / modules (Profibus-DP, HART, Modbus, etc.) as necessary for remote/distributed I/O communication to communicate with distributed I/O's @ Min. 12 MBPS or suitable other as per manufacturer standard or for connecting devices over network for communication / data acquisition from field instruments as per specifications / bidder's selection of communication facility with field instruments, variable AC drives, energy analyzers, etc. required to be monitored as per this tender scope / specifications.

(d) The data communication based on GPRS will be with required communication port and modem suitable for GPRS data communication on 4G /5G network of selected service provider for third party integration and remote data transfer data to central SCADA / Monitoring station of Client as required during detailed engineering for communication facility to transfer data from WTP to remote central control room of client for which bidder shall consider to provide required RTU / modem, GPRS modem, SIM Card, and other required communication facilities and include the same in their price. The required charges for procuring SIM Card / Broadband connection and it's renewal / operation charges during entire period of O&M shall be borne by bidder.

General specifications for HMI shall be as under:

1	HMI shall be with 10" Wide Size TFT Color LCD Touch Screen Display with 800 x 400 dots resolution as a minimum
2	HMI shall have LED Backlight
3	HMI shall have FRAM/ROM of 10MB and SRAM of 128KB as a minimum
4	HMI shall have 1 nos. 485 Port and 1 no. RS-232 port as a minimum. Ethernet port shall be available as an option
5	HMI shall be with 1 no USB Port to permit insertion of pen drive for Data Backup and 1 no. Mini USB port (for programming/printing, as required) as a min.
6	HMI shall have Built in RTC with Lithium Primary Battery
7	HMI shall be suitable to operate for ambient temperature of 50 deg C and 95% RH
8	HMI shall be provided with Built in Software for Viewing HMI Screen on LAN (with Ethernet Port)
9	HMI shall be provided with 32 GB Removable Pen Drive for Recording Historical Data & Streaming

Specifications for GPRS Modem shall be as under:

1	Modem shall support SIM900 Quad Band GSM/GPRS engine suitable to transfer data over GPRS for any 4G/5G or latest network
2	Modem shall have Built In RS232 Serial Interface Port/ Ethernet /Suitable port/SIM
3	Modem shall have Built In Network Status LED
4	Modem shall have Built In Sim Card Holder
5	Modem shall have configurable Baud Rate
6	Modem shall operate with Input Voltage of 24VDC
7	Modem must have auto reset facility when network resume

Contractor shall provide minimum of 3 sets of as-built control panel wiring drawings, PLC logic write-up, I/O Schedule/assignment, ladder diagram and other relevant documents in hard copy format and 3 sets in soft copy form on CDs. Soft copy format shall be in editable form to enable incorporating any changes in future. 3 sets of application program as back-up shall also be provided in soft form on CDs. All application programs shall be without password protection and as per final approved scheme ready to install and use by client and same shall be demonstrated by bidder prior to acceptance of system at site.

Bidder to note that the operation philosophy / logic specified anywhere in tender specifications is indicative only and same shall be submitted by successful bidder as per requirement and to ensure smooth and trouble free operation with minimum manual intervention during detailed engineering for review and approval and shall carry out all software development as per approved philosophy only.

Programming Software

The programming software should help in maximizing performance, save on project development time and improve productivity.

The programming software should be able to operate on Windows-10 or latest version at the time of supply.

The programming software shall have Online editing features which is used to modify the application program while the process is still operating.

Make system backup copies while the system is online.

Upload and down load programs to the PLC

Human Machine Interface (SCADA) Software

HMI shall display process scheme of entire treatment plant including Pumping Station showing status of all electrical drives, electrically operated valves and instrumentation (level, flow, dif. Level, process analyzers, field transmitters, LOH/ROF, etc.). Screens depicting entire pumping station / treatment plant and also for individual process units as well as each filter bed shall be developed and displayed at HMI with necessary process parameters / equipment status and operation buttons. It shall be easily possible to navigate through various screens.

The operator interface software, herein described as the HMI (Human Machine Interface) shall be common for engineering and as operator works station. - an integrated package for developing and running automation applications and also to be just running the automation application.

The HMI shall be designed for use in latest version of Microsoft Windows and shall use OLE, ODBC, DDE, OPC and ActiveX technologies for optimal performance and integration with other software systems.

The HMI shall have several Methods (relying on DDE server / OPC server / etc.) for collecting data from programmable controllers.

The tag database shall be organized in a hierarchy, each level represented by a folder that can be expanded or collapsed.

The HMI shall have the ability for the current value of a tag to be updated from the device it is connect to and stored in RAM so it is immediately accessible to all parts of the HMI.

The HMI shall have the ability to create a tag whose value is the result of an expression. The expression can be made up of mathematical operations, tag values, if-then-else logic and other special functions. The current value of the derived tag shall be stored in an analog, digital or string tag in a value table.

The HMI shall provide a Macro capability that will execute system commands, user defined commands and other macros.

The alarm system shall have the ability to define up to eight different severity classes to visually and audibly distinguish alarms.

The alarm system shall have the ability to use system default messages or create unique messages to describe an alarm log messages to a file, to a printer or to both suppress alarms for maintenance and tuning purposes and set up global alarm monitoring.

The alarm system shall provide a means of displaying up to 1000 tags that are in alarm. This alarm summary display shall be fully configurable.

The alarm system shall have the ability to create alarm log files periodically, at specified times and on event. This alarm log system shall have the ability to automatically purge old files after a specified time.

The HMI shall have the ability to trigger actions based on an event that has an expression applied to it. An expression is an equation containing tag values, mathematical operations, if-then-else logic, or other functions. An action shall have the ability to produce a variety of functions including, but not limited to, initiating a snapshot of tag values, displaying an error screen and changing a tag value.

The HMI shall have the ability to allow certain users or groups of users to access only certain parts of the system. The security shall be based on a series of codes. Each code shall allow the users, or groups of users, with security privileges for that code to access the HMI commands allowed by that code. Users shall be allowed to be assigned combinations of security codes, allowing for each user to access a different set of features.

The security system shall assign each person a user account with a login name, password, and any desired macros. The HMI shall have a minimum of 2-3 different security codes.

The HMI shall provide a graphics display editor for creating displays using graphic objects. The graphics display editor shall have the ability to drag and drop objects from a pre-configured graphics library, paste objects that are copied to the clipboard from another Windows application, and insert objects created by another Windows application using OLE. The graphic display editor shall allow the user to create libraries of graphic objects.

The graphic display editor shall have the ability to attach, as a minimum, the following control to objects: blinking colors, visibility, rotation, horizontal and vertical movement, resizing (width and height), fill and touch.

Additional requirements

The HMI package shall provide the following features:

Display status of Plant in a graphical and tabular format (i.e. running, stopped, fault etc.)

Display Analog values on the appropriate graphic screen.

Annunciator alarms associated with the area of the plant concerned including details of the time the alarm occurred

The HMI package shall also provide following facilities for the operator Station

- Adjust process set points
- Select process modes
- Acknowledge alarms
- View a journal of unacknowledged alarms
- View a journal of the last 200 alarms acknowledged and unacknowledged.
- Display process set points
- Provide real time and historic trending of local analogue values
- Provide data archiving of all local analogue values
- Prepare daily and weekly reports (providing details of daily and weekly throughputs against numbers of pump running hours, power usage, etc.)
- Display a total running hour's log of local transmission pump drives.
- Display preventive / planned maintenance schedules

Power monitoring/management using various analogue / digital inputs provided from the HT switchgear / PCC / MCC / VFDs / etc. for Plant.

Power monitoring/management – data communication with MFM using communication port as well as using various analogue / digital inputs provided from the HT switchgear / PCC / MCC / SS / VFDs / etc. for entire Plant / scope of this tender for various power parameters as specified in tender including required trends / bar graphs and for reporting. Display / report for power consumption for m3 of pumping machinery. Power consumption per day for today (till time), for previous day and for previous month for all major electro-mech equipment provided with MFM of power monitoring tool as part of starter and for all HT/ PMCC/MCC and for entire plant .

Preventive Maintenance Schedule based on operating hours and duration basis as recommended by vendor for all major electro-mechanical equipment.

For provided flow meter on inlet and outlet of treatment plant and for other as required, totalized flow data shall be displayed at HMI/SCADA as total flow today till time, total flow pumped for previous day and total flow pumped in current month till today and total flow pumped in previous month. Also the flow data of each day shall be presented in bar chart for last 90 days / 3 months and shall form part of reporting.

Operating hours shall be logged for all electrical drives irrespective of auto or manual mode of operation. In auto mode, the equipment if available, shall be selected for operation based on operating hours so as to achieve uniform utilization of all equipment. OH shall be displayed on HMI/SCADA along with status of respective equipment. In case of more than one working pump in a set, no two pumps shall start or stop simultaneously. The start & stop shall be having user programmable delay to be finalized during detailed engineering.

Report generation shall be done on daily, weekly and monthly basis from SCADA for submission

to client including all parameters and analysis data specified in tender and in the format and any other periodicity as required by clinet (owner's) engineer.

Display & report for power consumption per m3 for Power consumption per day for today (till time), for previous day & for previous month for total plant Discharge to be provided.

Time stamped data shall be available for operation of all pump / equipment drives including daily and total working hours of each pump / equipment drives and provided as part of report generation as required by client..

Any additional features required to assist in the effective and efficient operation of the WTP. Power monitoring/management using various analogue / digital inputs provided from the HT switchgear / PCC / MCC / VFDs / Soft Starters, etc. for WTP / CWPS.

Graphic screens shall be provided as follows but not limited to this:
Main and subsystem menus
Plant / Process overview (i.e. providing details of Nos. of pumps / blowers / equipment running, Flow, totalized flow, levels, process parameters / power supply status, etc.) for WTP.
Overview of power system
Overview of control system
Screens to permit viewing of process set points
Tabular screen of Pumping / Treatment Plant status and values
Running hours log for Pumping Station and treatment plant process pumps, etc.
Trends for important process parameters
Trends for important power parameters

The screens shall display data commensurate with their size and the area of and number of Plant items covered. In addition to the specific screen requirements stated above, any additional screens to ensure comprehensive coverage of the Works needs to be provided.

A comprehensive screen navigation system shall be provided giving access to all screens via a system of menus and short cuts (i.e. it shall be possible to follow the process from one screen to another by clicking the mouse cursor on screen 'hotspots' to effect the move from one screen to another).

The sample rates required for the displaying of trends shall typically be one sample every 15 seconds for flow values and one sample every 30 seconds for levels. The system shall be capable of storing real time data for one day and historic data for 90 days.

The sample rates for archiving shall be the same as for trending. The archives shall be stored in daily files. The system shall provide capacity to store archives for 90 days. A warning alarm shall be provided to the operator to advise that archiving to disk should take place or archived data will be overwritten.

The data derived from archiving to the MMI and the archived data viewed using the trend facility.

The HMI shall have the ability to record specific tag values under certain conditions. Several models shall define these conditions. This data that is collected shall be stored in MS SQL format for displaying in trends, archiving for future processing or analysis, and/or using with third-party software, such as FoxPro, Crystal Reports, and Microsoft Excel, for display or analysis .It shall be possible to log historical data directly to an ODBC compliant database

The Contractor shall provide a disc drive with the MMI in order to download archive data or to upload previously stored archive data onto electronic storage media.

❖ **Uninterruptible power Supply (UPS)**

UPS of suitable capacity as per following specifications for 60 minutes back-up shall be supplied for entire load of instrument control panel including PLC and essential / critical instrument supply for necessary shut-down in case of power failure.

(a) The UPS shall be floor mounted, self-contained and metal clad and shall be suitable for supplying a nonlinear load.

(b) It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact touch.

(c) The UPS shall be on-line type incorporating a six-pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch that shall operate in event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply.

(d) The UPS shall incorporate a DC under voltage trip circuit to Electro-mechanically trip the UPS output in order to protect the batteries.

(e) The noise level of the unit shall not exceed 60 dB (A) at 1 m from the UPS cabinet.

(f) The output of the inverter shall be a sine wave having less than 2% THD for linear loads and less than 4% for 50% nonlinear loads. It shall be suitable for load power factors 0.7 lag to 0.9 lead.

(g) The unit shall have a dynamic response such that 100 % step load causes an output voltage transient of less than ±4% with a recovery of less than 4ms. The load crest factor shall not be less than 3:1.

(h) Indicators shall be provided for the following
i. UPS status
ii. PS alarm conditions

(i) The UPS shall provide volt free contact outputs for the following purpose:
i. Warning, (viz., low battery voltage)

(j) The UPS shall have an overloaded capacity of 150% for 30 seconds and shall be protected in the event of a short circuit of the output.

(k) The batteries shall be housed, within a separate matching battery cubicle suitable for location adjacent to the UPS. The batteries shall be of the rechargeable, sealed maintenance free lead acid type. The battery supply to the UPS shall be via a fused load break switch disconnecter circuit breaker. The battery recharge time to 90% of full charge shall be approximately ten times the discharge time at full load.

(l) Terminals shall be shrouded to prevent accidental contact
The Uninterruptible Power Supply (UPS) System with SMF Lead Acid battery shall conform to the minimum following specifications:

i. Input

Input Voltage	:	230 V, ± 5%
Frequency	:	50 Hz ± 5%
Nominal DC input (Battery)	:	Bidder to design and submit calculations

ii. Output

Output	:	230 V AC,applicable KVA with 25 % margin as per Load Calculation
Regulation mode	:	± 1%
Load power factor	:	0.8 to unity
Duty	:	Continuous
Ripple on DC	:	< 2%

iii. General

Principal of operation	:	Shall be solid state, pulse with Modulation (PWM)
Cable entry	:	Bottom
Cooling method	:	Forced air
Type of Battery	:	Sealed Maintenance free

Additionally **CVT** (Single phase Constant Voltage Transformer) as per following specifications shall be supplied along with UPS (to be considered as part of Item of UPS) for entire load of instrument control panel including PLC/UPS/PC & instrument for protection in case of any higher jerk/spike in incoming power for each ICP.

Capacity: as per capacity of UPS
Input: 180-270 VAC,
Output: 230 V ± 1%.
Efficiency: 85 % (with Full Load)

UPS sizing calculation shall be submitted by bidder for approval for entire panel / Instrument system load and UPS shall be selected with min. 25 % spare margin.

❖ **INSTALLATION MATERIALS:**

Vendor shall supply all erection hardware required for the installation of complete instrumentation forming part of this tender.

This includes items like cables, cable glands, junction boxes, instrument valves and manifolds, mounting accessories, impulse piping / tubing, pipe/tube fittings, pneumatic signal tubes, air line pipes and fittings, filter regulator, insulation material, cable duct and trays, conduits, identification tags, structural material required for instrument supports and trays etc.

A) CABLES:

Vendor is fully responsible for the sizing of all cables in their scope of supply considering factors like maximum distance between Control Room and the Unit. Specifications for cables for analog signals, digital signals and instrument power cables shall be as follows:

Cables For Analog Signals:

Cables shall be of 660V/1100V grade, single or multi-pair cables, annealed, tinned, high conductivity 1.0 sq.mm stranded copper conductor, PVC insulated two cores twisted into pair, laid up collectively, individual pair shielded and overall shielded with aluminium mylar tape, ATC drain wire running continuously in contact with aluminium side of the tape, PVC inner sheath, armoured with galvanised steel wire overall sheathed with PVC, conforming to IS:1554 & IEC:189 Part II shall be used for analog signals. Sequential marking of the length of the cable in meters shall be provided on the outer sheath at every one meter. For multiplier cable ,Pair identification as per BS 5308 Part-II marking pair no. for each pair shall be provided at maximum 50mm between two consecutive numbers.

Cables For Digital Signals:

Cables of 660V/1100V grade, multi-core cables, multi-stranded high conductivity annealed 1.0 sq.mm stranded, tinned copper conductor, PVC insulated, overall shielded with aluminium mylar tape, PVC inner sheath, armoured with galvanised steel wire overall sheathed with PVC, conforming to IS:1554 & IEC:189 Part II shall be used for digital signals. Sequential marking of the length of the cable in meters shall be provided on the outer sheath at every one meter. The embossing/engraving shall be legible and indelible. Control cables having 6 cores and above shall be identified with prominent and indelible Arabic numerals on the outer surface of the insulation. Colour of the numbers shall contrast with the colour of insulation with a spacing of maximum 50mm between two consecutive numbers. Colour coding for cables upto 5 cores shall be as per IS.

Cables For Instrument Power Supply:

Cables of 660V/1100V grade, multi-core cables, multi-stranded high conductivity annealed 1.5 sq.mm, stranded, tinned copper conductor, PVC insulated, PVC inner sheath, armoured with galvanised steel wire overall sheathed with PVC, conforming to IS:1554 & IEC:189 Part I & II shall be used for instrument power supply. Sequential marking of the length of the cable in meters shall be provided on the outer sheath at every one meter

Fiber-Optic Cable:

1) Optical fiber cable shall be Single mode multiple cores (6), galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor application so as to prevent physical damage.

2) The core and cladding diameter shall be 9 +/- 1 micrometer and 125 +/- 1 micrometer respectively.

3) The outer sheath shall have flame retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacture, progressive sequential on-line marking of length in meters at every meter on outer sheath.

4) The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. steel central member, loose buffer tube design, 4 fibers per buffer tube, interstices and buffer tubes etc.,

5) The central fiber optic unit shall be designed to house and protect the fibers from damage due to forces such as crushing, bending, twisting, tensile stress and moisture, wide temperature variations, hydrogen evolution etc.

6) All fiber optic cable shall have a minimum service life span of 25 years

7) The offered cable shall meet requirement of mechanical characteristic & tests specified in latest TEC specifications

8) The cable shall conform to the following standards.

   i) ITU-T Recommendations G.652

   ii) Electronic Industries Association, EIA/TIA 455-78A, 455-3A, 455-62A, 455-164A/167A/174, 455-168A/169A/175A, 455-176, 455-59, EIA/TIA 598, EIA 455-104.

   iii) International Electro technical Commission standards, IEC60304, IEC60794-1-2, IEC60811-5-1.

   iv) Bellcore GR-20

   v) Telecom Engineering Centre (TEC), Department of Telecom, Govt. of India (TEC-spec no-GR/OFC-17/01, June 2007)

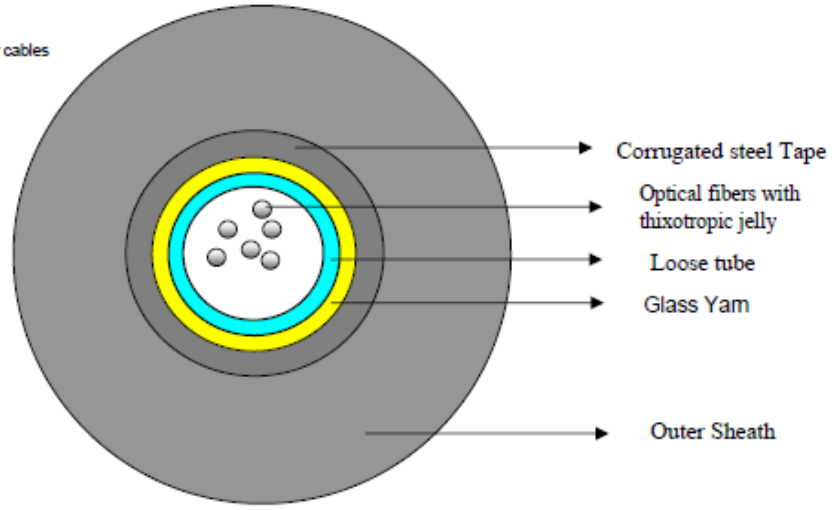
9) All testing of the fiber optic cable shall be as per relevant IEC, EIA and other international standards. The Contractor shall submit the type test reports along with test reports.

10) Cables shall be suitable for laying in conduits and underground buried installation.

Specification (Indicative) of Fiber Optic Cable

CABLE DESCRIPTION

1 9/125 micron Single-mode Armored Optical Fiber cables
2 Designed with a Loose tube construction
3 Tubes are gel filled to ensure protection against moisture ingress
4 Designed for use in the following applications like Backbone cabling, Campus site cabling & Outdoor Ducts or Direct Burial applications
5 Cable contains upto 6 Fibers
6 Each loose tube contain 6 Optical Fibers
7 HDPE Sheath



Sr.No.	Parameter	Unit	Specifications
1	Typeof Cable		6F Unitube Armoured OpticalFiberCable
2	Fiber		Single Mode / Multmode Fiber
a)	Fibre size	um	9/125/250 (OS2)
b)	No. of Fibers / Loose Tube	No.	6F
c)	Fiber Identification		
	6F		BL, OR, GR, BR, SL & NT
3	Optical parameters		
	For Single Mode		
	Attenuation @1310nm	dB/Km	≤ 0.34 (MAX)
	Attenuation @1550nm	dB/Km	≤ 0.22 (MAX)
4	Loose Tube / Tight Buffer		Loose Tube
a)	Material		PBTP
b)	No. of Loose Tubes	No.	1
c)	Diameter (Nominal)	mm	2.8
d)	Colour of Loose Tube		Natural
e)	Sequence of elements in core		NA
f)	Loose Tube Gel		Thixotropic Gel
5	Jacketing		
a)	Material		HDPE
b)	Colour		Black
c)	Nominal Thickness	mm	2.0
d)	Overall Diameter (Nominal)	mm	10.0
6	Strength Members		Yes
a)	Type (Peripheral)		Water Swellable Glass Yarn
7	Armouring		
a)	Type		Corrugated Steel Tape
b)	MS Tape Thickness		> 0.15
8	Cable weight (Nominal)	Kg/Km	87
9	Standard Length	Mtrs	2KM+5%

Bidders' stamp & initials

10	Tensile Strength	N	1250
11	Type of Packing		Wooden Drum

Laying of Cables:
Cables shall be laid on trays, in trenches, conduits, ducts as necessary. Instrument cables shall not be buried in ground as far as possible. Cable joints in instruments signal and power supply cables shall not be permitted. In case if some of the instrument cables are to be buried in the ground, it shall be as per standard/good engineering practice and shall be subject to client's/consultant's approval.

The contractor shall also supply necessary materials such as junction boxes, glands, lugs etc. required for termination of cables. Each cable shall be terminated to individual panel/terminals box. Cable glands shall be of Nickel plated Brass and of Double Compression Weather proof type.

A distance of minimum 300 mm shall be maintained between the cables carrying low voltage AC & DC signals and a distance of minimum 600 mm shall be maintained between cables carrying HT & LT cables.

Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by contractor. All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedule. Identification tags shall be securely fastened to the cables at both ends.

B) CABLE GLANDS:
Cable glands shall be nickel-plated brass and shall be of double compression type suitable for armoured cables.

Flame proof glands wherever required shall be with Ex (d) certification.

C) INSTRUMENT VALVES (MINIATURE TYPE) AND MANIFOLDS:
Body rating shall be as per piping class or better. Valve body and Trim material shall be SS316 as a minimum. Packing material in general shall be PTFE. Valves and Manifolds shall be of forged type only.

D) PIPE AND TUBE FITTINGS:
Tube fitting shall be flareless compression type and of three piece construction.

Ferrule shall be of SS in general.

Socket Weld type forged pipe fitting of suitable material and rating shall be supplied for pipe fittings. The minimum rating shall be 3000 lbs. Weld neck fittings shall be used where socket weld is not allowed by piping class.

For air service instrument brass fittings suitable for use on copper tubes conforming to ASTM B 68 / B 68M shall be used. It shall be manufactured from Bar Stock or equi and shall be nickel plated.

E) CABLE TRAYS:
All branch cables/tubes, cables on various civil units/structures shall run on cable trays only.

Cable trays shall be made out of galvanized mild steel sheets of 2.0 mm thickness with required accessories. All material shall be hot dip galvanized as per IS 2629. The width shall be so selected that 10-20% space is available for future use.

Suitable cable clamps shall be supplied for binding cables / tubes at every 500mm.

F) JUNCTION BOX:

Junction Box material shall be Cast Aluminium (LM-6) only and shall be weather proof to IP-65. Flame proof Junction box wherever required shall be with Ex (d) certification

The boxes shall have terminals suitable for a minimum of 4 mm2 cable termination mounted on rails. 20% spare terminals shall be supplied in junction boxes.

Each junction box shall have 10% or minimum 2nos., whichever is higher, spare entries of each size. Spare entries shall be provided with plugs.

Alternately junction boxes housing shall be of polycarbonate MOC and of reputed make.

G) CABINETS FOR FIELD INSTRUMENTS

A Cabinet shall be provided for enclosing instruments and associated accessories which are mounted outside the control panel such as transmitter, LPU, terminal blocks etc. at all measurement locations.

It shall be fabricated from cold rolled steel with powder coating sheet of standard gauge and shall be suitable for wall mounting or pedestal mounting as required.

The cabinet shall be properly painted from inside and outside by paint shade RAL 7032.

The cabinet shall conform to IP-65 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.

❖ **INSPECTION & TESTING**

Inspection of offered equipment/items at manufacturers' works' shall be done by the Client/PMC/TPI as specified here in as per relevant inspection and testing standards and as per approved, quality assurance plans, technical data sheets, documents and drawings.

Inspection Criteria of Various Major Equipment/Items at Manufacturers' Works:

Major instrumentation system electrical equipment/items as specified below, shall be tested and inspected at vendor manufacturers' works as narrated, prior to dispatch to ensure compliance with the specifications, requirements and applicable codes and standards and approved quality assurance and testing plans by the Client/PMC/TPI.

➢ **PLC-SCADA Panel**

100% quantity of PLC-SCADA based Control panels, tests (FAT) shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

SCADA Screens, operation logic, report format and report generation, etc. shall be witnessed at site by the Client/PMC/TPI. Report format shall be finalized as per client requirement at site.

- **Electro-Magnetic Flow Meters**

Flow Meters ≤ 500 mm dia. NB: Wet calibration tests carried out internally and test certificates shall be submitted for review and acceptance by the Client/PMC/TPI.

Flow Meters > 500 mm dia. NB to ≤ 900 mm Dia. NB: Wet calibration tests of **5% quantity or one number (whichever is higher)** of each class type and size shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

Flow Meters > 900 mm dia. NB: Wet calibration tests of **10% quantity or one number (whichever is higher)** of each class, type and size shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

Wet calibration (3 point calibration, 3 separate point) test shall be conducted as per governing standards approved Quality Assurance Plan (QAP) by Client/PMC/TPI as applicable shall be as specified below.

All electro-magnetic flow meters shall be provided with manufacturers' calibration certificates.

Manufacturer shall test all the meters internally and shall provide their internal test records for hydrostatic test along with material test certificates, Dimensional check certificates etc. and as per approved QAP for review, record and dispatch clearance prior to dispatch of materials.

The flow calibration and testing should be as per ISO 8316 (Calibration by Volumetric Method) or ISO 4185 (Measurement of fluid flow in closed conduits - Weighing Method) and shall be calibrated for minimum 3 Point Calibration (3 Separate point). Performance Type Testing Certification (ISO 9104) is strictly not acceptable. The manufacturer shall also have a flow calibration and testing facility in India or abroad so that methodology and procedures can be verified and each meter shall be tested and wet calibrated before shipment by the manufacturer. The flow calibration and testing facility shall be duly accredited in accordance with ISO 17025 standards.

The manufacturer's flow calibration and testing facility if in India shall be preferably accredited by National Accreditation Board for Testing & Calibration Laboratories (NABL). If the manufacturer is outside India then their flow calibration and testing facility should be accredited by a reputed International authority.

Further, if manufacturer test bed in India is not accredited to NABL or for flow meters imported from outside India then,

- The flow meter shall be calibrated/witnessed for wet calibration at the facility of FCRI, Palakkad, Kerala or other FCRI facility in India.
  OR ALTERNATIVELY,
- The flow meter shall be calibrated/witnessed for wet calibration at any NABL accredited laboratory / facility in India (laboratory to meet above mentioned requirements for conducting wet calibration test)
  OR ALTERNATIVELY,

- For flow meters imported from outside India, contractor shall arrange to inspect/ witness for wet calibration by a reputed third party inspection agency (SGS/ Bureau Veritas/TUV) as per approved inspection plan at manufacturer works at no extra cost. The test/performance certificates and relevant supporting documents shall be submitted to Client/PMC/TPI for review and approval. The meter(s) shall be dispatched only after obtaining dispatch clearance from Client. Additionally if desired by Client a simultaneous inspection/witness for wet calibration shall be offered virtually to Client/Client representative.

➢ **Cables**

For all types of control and signal cables, if the quantity of each type of cable where length of cable is **≥ 1000 meters,** tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

All other items shall be cleared for dispatch based on review of material test certificates / manufacturers' test reports' by the Client/PMC/TPI.

All expenditure pertaining to inspection including to and fro travel, local conveyance, lodging and boarding etc. shall be borne by the Contractor for minimum 2 representatives of Client/PMC/TPI Agency.

Field tests as per approved procedures/procedures available with Engineer-in-charge or his authorized representative shall be performed on the Instrumentation system/equipment before it is being put into service. All required test equipment shall be arranged by the Vendor/Contractor. Test reports shall be approved by the Engineer-in-charge before acceptance of the equipment and complete plant.

VENDOR DATA REQUIREMENT
(INSTRUMENTATION)

Sr. No.	Description	Info. / Review	As-Built
1	Piping & Instrument Diagram	*	*
2	Instrument index	*	*
3	Vendor List for Instruments & accessories	*	
4	Sizing Calculations	*	
5	Utility requirements	*	
6	Instrument Specifications and data sheets	*	*
7	Detailed loop drawings	*	*
8	Panel front arrangement	*	*
9	Wiring diagram for panels	*	*
10	Cable Schedule	*	*
11	Instrument Installation drawings	*	*
12	Bill of Material for installation items	*	*
13	Inspection and Test procedures	*	
14	Test Certificates and certific. from statutory bodies	*	*
15	Complete catalogues with part list for all vendor supplied instruments, controls etc.	*	
16	Installation, Operation and maintenance manuals		*

NOTE :- This list indicates the minimum drawing and document list. However vendor shall also furnish any other drawing or document required to be furnished during the course of job execution.

LIST OF APPROVED VENDORS FOR INSTRUMENTATION SYSTEM

Item Description	Approved Vendors
Water Quality Analyzers (pH, Turbidity, Residual Chlorine, etc.)	E+H, Emerson, Hach, Yokogawa, Xylem / WTW, Krohne, Forbes Marshall (Forbes Marshall make for pH analyzer & Conductivity Analyzer; Optex, Japan make for Turbidity analyzer)
Laboratory Instrument (Portable / Handheld) - pH / Turbidity / TDS (conductivity meter), etc.	Hach, Orion, YSI, Radiometer, Denver, Hanna
Ultrasonic Type Level / Diff. Level / Open Channel Flow Transmitter	Endress+Hauser, Siemens, Krohne, Vega, Emerson, ABB
Hydrostatic type level transmitter	ABB, E+H, Siemens, Krohne Marshall, Emerson
Electro Magnetic Flow Meter	ABB, E+H, Krohne Marshall, Yokogawa, Siemens, Aarohi
Differential Pressure / Pressure / Temperature Transmitter	ABB, Emerson, Fuji, Honeywell, Siemens, E+H Yokogawa,
Pressure / Compound Pressure Gauges	Wika, General Instru. Consortium, Pricol, Manometer (I) P. Ltd., Baumer, Excel Instrument, Precision Mass, Forbes Marshall, H. Guru
Displacer / Float / Buoyancy Level Switch	ATMI, Baumer, E+H, Nivelco, P+F, Pune Techtrol, SBEM, Levcon, Nivo/Toshbro
Float & Board type Level Gauge	Nivo/Toshbro, Pune Techtrol, Revathi, SBEM , Levcon , Jayati Instrumentation
Programmable Logic Controller (PLC) System / HMI/SCADA Software	ABB, Rockwell (Allen Bradley), Schneider, Siemens, Honeywell
Panel Enclosures	BCH, Bartakke, Eldon (nVent Hoffman), Enklotek, Rittal, Pyrotech
DC Power Supplies (DIN Rail mounted)	Phoenix, Omron, Aplab, IFM, Schneider, Allen Bradley, Siemens, Intex, Microtex, Schneider, IFM, Meanwell
GSM/GPRS Modem	Maestro (Lantronix), Axitech, Netgear, D-link, Moxa, Robustel, Teltonika
Ethernet Switch	D-Link, Rockwell, Siemens, Schneider, Cisco, Phoenix Contact
Media Converter	Digisol, TP link, Microtek D-link, Moxa
Receiver Indicators (Panel Mounted)	Masibus, Nivam, Nishko, Selec , Yokogawa, Multispan
Miniature Relay	ABB, Omron, Phoenix, Schneider, Rockwell
Indication Pilot Lamps (LED Type)	Teknic, Schneider, Siemens, Salzer, Vaishno
Push Button/ Selector Switch (with NO/NC Element)	Teknic, Schneider, Siemens, Salzer, L&T, Rass, Vaishno, Kaycee, Binay
Lightning Protection Unit	Rittmeyer, MTL, Crompton, P+F
Terminals	Elmex, Phoenix, Wago, Connectwell

Panel Wires	Finolex, Havell's, R R Kabel, Lapp Cable, L&T, Polycab
Panel Illumination	Philips, Crompton, GE, Bajaj, Havells, Surya
Alarm Annunciator	Aplab Ltd., Minilec, IIC, ICA, Protons
Computer System including Monitor / Laptop computer	HP-Compaq, Dell, Acer. IBM – Lenovo, Asus
Anti-virus software	Quick heal, McAfee, Norton
UPS	Emerson (Liebert / Vertiv), Schneider (APC), Merlin Gerin, Socomec, Hirel-Hitchi, Eaton, Numeric
SMF/ Lead Acid Batteries	Panasonic, Exide, Base, Prestolite, Rocket,Amron, Tata-Green
LED / LCD TV	Samsung, Sony, Panasonic, LG
Printer (Inkjet/Laser Jet)	HP, Canon, Samsung, Ricoh, Epson
Instrument Cables (Power , Signal, Control)	Associated Cables, Associated Flexible and Wires P.Ltd. Brook Cables, Thermo cables, Udey Pyro, RPG Cables. Polycab, Rolliflex, RR Kabel, Havells
Fiber optic cable	Tyco-AMP , Panduit, Systimax, D-link, R & M
Communication Cables	D-Link, Delton, Finolex, Lapp Cable, Molex, Udey Pyro
Junction Box (Metallic / Cast Alu.)	Ex- Protecta, CEAG, Sudhir, Baliga, FCG, VSM Plast, Phoenix Mecano, Hensel
Junction Box / Enclosures (Polycarbonate / ABS or such Polymer)	EPP Composites, Eaton, VSM Plast, Phoenix Mecano, Hensel, Legrand, Sintex
Cable Glands	Ex-Protecta, Braco, Comet, HMI, 3D, Sudhir, Connectwell
Cable Tray (GI / FRP), Any Other FRP item	M.M.Engineering, Globe, Jacinth, Silver line Power, Shree Krishna Electrical, Sumip, Fiber Tech Composite/ Satyam Composites, Dudhat Infra, Indiana ,Legrand, Sharda , Vatco , Super Electro, Kismat Engitech LLP
Instrument Valves and Manifolds, Tube Fittings, Pneum. Brass Fittings	Excel Hydropneumatic, Industrial Enterprise, Festo, Multimetal Industries, Placka, SMC, Technomatic, Wesmec, Fluid Controls, Aptek , Anmol (Superlok), General, Smart, Instrument Consortium
Solenoid Valves	Asco, Rotex, Schrader, Janatics, Uflow
Air Conditioners	O General, Hitachi, Panasonic, Voltas, Mitsubishi, Blue Star, Carrier, LG, Samsung, Daikin
Office Furniture	Godrej, Blind Men's Associations, HOF, Equi. reputed

The contractor shall distinctly understand that it will not be their prerogative to insist on a particular brand from the list, final selection will be done with the approval of Engineer in charge.

09 CHAPTER
OPERATION AND COMPREHENSIVE MAINTENANCE OF WATER TREATMENT PLANTS (GENERAL)

PART A: SCOPE OF WORKS

1.0 The contract includes **operation and comprehensive maintenance** of entire Water Treatment Plant (deemed to include all units/items/equipment within the scope of work) **on round the clock basis for a period of 24 Calendar Months (Two Years, coinciding with 1 year DLP) after successful completion of trial run of three months and acceptance of Plant.** Guidelines stipulated in Manual on Water Supply and Treatment, Latest Edition, published by Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, New Delhi, shall be followed. The O & M period starts after completion of three months of trial run and acceptance of plant by engineer-in-charge. Additional information is given in the following sections to facilitate the monitoring works. Contractor shall note that preparation of Operation and Maintenance Manual for the WTP designed and set up by them is included in Scope of Work. This manual shall be duly got approved from Employer prior to commissioning.

The same may be extended for the further period if the client so desires at mutually agreed terms & conditions. However, scope of work will remain unchanged.

2.0 The Water Treatment Plant set up on turnkey basis shall be operated and maintained by the contractor including all works. **CONTRACTOR HAS TO INCUR ALL THE COSTS, TAXES / GST, DUTIES, TRANSPORTATION, LABOUR, MACHINING, WELDING, REPAIRING, REPLACING AND MAKING GOOD ANY AND ALL PARTS / PLANT EQUIPMENT INCLUDING SAPRES & CONSUMABLES FOR ENTIRE PLANT UNDER THE SCOPE OF THIS TENDER, ANY OTHER CONSUMABLES, CHEMICALS FOR LABORATORY, ETC. TO SUMMARIZE, ONLY RAW WATER, POWER, ALUM & CHLORINE (WITHIN WTP PREMISES AT ONE POINT) & DIESEL FOR DG SHALL BE SUPPLIED FREE OF COST BY CLIENT AND REST ALL COST INCURRED WITH RESPECT TO OPERATION & MAINTENANCE INCLUDING ANY STATUTORY APPROVALS (PAYMENT OF FEES FOR STATUTORY APPROVAL & ISSUING REQUIRED AUTHORIZATION / LETTERS SHALL BE BY CLIENT BUT LIASIONING & REST ALL REQUIREMENTS FOR OBTAINING APPROVAL SHALL BE BY THE CONTRACTOR) DURING SPECFIED PERIOD OF O&M CONTRACT SHALL BE BORNE BY SUCCESSFUL BIDDER (CONTRACTOR).**

2.1 Average Power Factor for the supply company Power Bill must be greater than 0.95 and if any Penalty/Charge levied due to low Power Factor, then the same shall be recovered from the contractor without any reasons in addition to the penalty for each instance of non-maintenance of desired power factor of 0.95 or better as per specifications at PCC/PMCC of proposed WTP each month as mentioned separately below. All capacitor panel/s must be kept in working condition to maintain power factor generally of 0.98 lag or better by the contractor. Penalty on account of poor power factor / power factor not maintained as specified at plant PCC/PMCC client

reserves right to impose penalty and as explained elsewhere will be recovered from the contractor from his monthly O&M bill.

3.0 The Contractor will be held responsible for O&M and satisfactory performance of the WTP. Major components and works shall include the following but not limited to:

a) Operate the plant efficiently for TWO years (24 hours/day & 365 days/year) including all consumables, parts or components, labor transportation and other charges, except for cost of power, chlorine, PAC / Alum, diesel for DG Set and supply of raw water. Power cost would be borne by Employer. Raw water shall be supplied by employer. PAC / Alum and chlorine and Diesel for DG Set (during Trial run as well as during O&M period) shall be supplied free by employer. However, bidder shall supply any other chemical/coagulant, etc. as required in order to achieve the treated water quality as per tender.

PAC / Alum & Chlorine shall be made available at one point within proposed WTP premises. However, all cost pertaining to loading / unloading and transportation up to required place, loading, etc. of PAC/Alum and Chlorine Tonners (Filled and empty as applicable & including loading/unloading of empty tonners returned for filling) shall be in bidder's scope and included in bidder's price.

b) Operate and maintain all units and equipments of the Water Treatment Plant as per the requirement of the process to meet continuously and consistently desired treated water characteristics in conformity with specifications and CPHEEO guidelines; maintain all equipment in good working condition as per the O & M manual as prepared by the contractor and duly approved by the Employer.

c) Attend breakdown of civil, mechanical, electrical, piping and instrumentation works and maintain the plant and equipment through out the Contract Period.

d) The operation and maintenance service provided by the Contractor for the period specified in the Contract shall ensure the continuous operation of the Plant and that the breakdown or deterioration in performance, under normal operating conditions, of any items of Plant and equipment and component parts thereof is kept to a minimum.

The contractor shall determine operating parameters, select settings (chemical dosages, etc.) and generally optimize the process, and working of the treatment plant. Excessive chemical dosing i.e. dose more than / less than normal should be avoided.

e) The Contractor shall adhere to the manufacturers' recommendations with respect to equipment maintenance, consumables, the types and grades of lubricants to be used, frequency of lubrication, adjustments to be made regularly and recommended spares to be held in store.

The contractor shall provide **timely planning** and **regular procurement of all required spares and consumable including chemicals, chlorine tonners, grease, lubricating oil, cleaning agents, laboratory reagents etc.** Contractor shall arrange for the requirement well in advance.

f) Maintaining Logbooks / Records of the work carried out to keep them in good working condition. He shall obtain approval of the format of logbooks and records from Employer.

g) The Contractor shall prepare and implement an effective plant maintenance program in consultation with the Employer. It is absolutely the Contractor's responsibilities to look after all sorts of maintenance whether routine, preventive or break down or any other type of maintenance. The Contractor will be responsible to carry out day to day as well as periodic maintenance necessary to ensure smooth and efficient performance/running of all equipment.

h) Submission of daily and monthly O & M report in the format as mutually agreed between client and contractor.

i) Carry out regular and frequent sampling, analysis and result recording of raw, clarified, treated water & any other intermediate process parameters as per the procedures laid out by the Owner and in conformity with standard methods.

j) Employ appropriate and skilled manpower, provide all tools, tackles, spares, consumables, equipment, laboratory instruments, glassware and chemicals, reagents etc. required for effective implementation of the Services detailed above.

k) Area lighting - Daily on/off operation and routine cleaning of all type of lighting / electric fixtures including fans / exhaust fans, etc. Replacement of lamps / Tubes / Fans in case of failure at contractor's cost.

l) Maintenance of garden – Normally watering the trees once a day or more if required. Grass cutting, removal of shrubs, weeds, around tree to be done as directed. Remarking the ponds around the tree after loosening with soil with supply of additional earth, if required. Cutting of branches, if required, for straight growth of tree/plant and development of garden.

m) All buildings, bathroom, toilet to be kept, swept, cleaned and washed daily. Consumable requirement for cleaning such as acid, harpic, phenyl, air freshner, washing powder, brooms, wire brushes, duster, bamboos, toilet soap, kharata (broom) shall be provided and used as required. All ventilators, windows/doors to be cleaned and to kept in good aesthetic condition.

n) To keep watch on overflowing of sump. If such overflow takes place the agency shall make it good and shall have to bear the damages caused to surrounding properties.

o) Maintaining laboratory and its all equipments. All materials, equipment and labour shall have to be employed by the agency to maintain the same.

p) Contractor shall ensure that the treatment plant is run on continuous basis and shut down if any subject to obtaining prior permission / approval of the employer. Generally major repair encountered in any unit shall be attended as quickly as possible.

q) Contractor shall submit six copies of the O & M Manual for approval of Employer, which may be modified, if required by Employer, and two copies would be returned by Employer duly approved and signed.

r) The contractor shall monitor the performance of the Water Treatment Plant, conduct the analysis of various parameters as indicated in tender specifications / requirements for the inlet raw water, clarified water, & treated water (Filter outlet). Contractor shall initiate and take adequate actions to ensure smooth and satisfactory performance/ running of the plants on a 24 hours/ round the clock basis.

s) For the smooth running of the plant all the required equipment, machineries, fittings & accessories, major and minor spares, consumables including chemicals, greases, lubricants, luminaires, all cleaning agents, packing, rubber sheet, laboratory reagents, all hardware, required quantity of white wash, oil paint color, all types of synthetic enamel / epoxy paint, material required for house- keeping and cleaning etc. are to be brought by the contractor. The quality of all consumable and spare etc. i.e. technical requirements as per manufacture recommendation shall remain unchanged.

t) Deleted

u) Deleted.

v) The contractor shall hand over the plant back to CLIENT on expiry of his contract in fully working condition satisfying the requirement of treated water. All the electrical, mechanical and instrumentation including standby shall be in perfect working condition.

4.0 The Contractor shall procure, keep at site and use necessary tools, tackles and safety equipments for day to day routine maintenance, preventive maintenance and break down maintenance. Also minor and major repairs to the equipment involved in the plant have to be carried out by the contractor during the O&M period. Contractor shall submit report, discuss and finalize with the Employer on the major repairs required to be carried out and how these repairs will be undertaken, to the satisfaction of the Employer and obtain written approval from the Employer before carrying out any major repairs.

4.1 The scope also includes cleaning of various units, clarifier, flocculator, removing of foreign materials like debris, sand, fish, frogs or any other dead or live animals and also cleaning of strainers of each pump quarterly so that required quantity of water is treated properly.

4.2 The disposal of the foreign particles like sand, dead or alive animals etc. from all the units of the plant to suitable place as shown by CLIENT is in the scope of contractor.
The scope of works also includes the calibration of all meters as required e.g. pressure gauge, Ammeter, voltmeter, relay, trivector meter, Energy meters, temp scanners, flow meters etc. for measurement of accurate readings.

5.0 Scope of CLIENT will be only to the extent of supplying raw water and bear the energy charges to be paid to Power Supply Company and supply of alum and chlorine at on point within WTP premises.

PART B: OPERATION AND MAINTENANCE SPECIFICATION

1.0 SUFFICIENCY OF TENDER

1.1 The prices entered in the Price Schedule shall, except in so far as it is otherwise provided, be deemed to cover all the Contractor's obligations under the Contract and all matters and things necessary for the operation and maintenance of the Plant. Particular requirements set forth in the Specification are given without prejudice to the aforementioned general obligations of the Contractor.

2.0 DOCUMENTS / INSTRUCTION FURNISHED BY THE EMPLOYER

2.1 The Employer may issue at such times as he may think proper during the contract period instructions as may appear to him to be necessary for the guidance of the Contractor in the operation and maintenance of the Plant. The Contractor shall be bound by the same, obey and execute.

2.2 The Contractor shall acknowledge the receipt of such instructions in writing or by fax / e-mail. The Contractor shall carefully check all such instructions before commencing any Works. The Contractor shall inform the Employer in writing, within 3 (three) days from the receipt of the same, of any errors or omissions discovered, or of the difficulty to execute any Works or part thereof in compliance with the written instructions received from the Employer. Failing to do so contractor shall be liable to execute at their own cost the necessary alterations to any Works resulting from these errors or omissions.

2.3 The Contractor will also be furnished with two copies of all instructions as may be issued by the Employer. One copy of all such O & M manuals and instructions issued to the Contractor shall be kept in his office at the site. The O & M manuals or instruction shall be considered valid only if the Employer has signed it.

3.0 CONTRACTOR'S ORGANISATION & ADMINISTRATION OF THE CONTRACT

3.1 The Contractor shall provide experienced administrative, managerial, technical, supervisory, non-technical personnel and labour necessary to operate and maintain the plant properly, safely and efficiently on a continuous 24 hours basis for the full term of the O & M Contract Period. During O & M period if any expert / technically knowledgeable / specialized persons or manpower needed, he shall have to arrange & bear / pay any and all cost, charges, fare, allowances etc. for the same. The employer will not pay any cost / charges for the same.

3.2 The qualifications and capability of the Contractor’s personnel shall be appropriate for the task they are assigned to perform. The staff provided shall be fully trained in the operation of the various units of the Treatment Plant before being given responsibility for operating any part of the Plant. If in the opinion of the Employer, any member of the Contractors staff is considered to be insufficiently skilled or otherwise inappropriate or not doing the work properly he is required to perform, he shall be replaced by the Contractor with a person with the appropriate skills and experience for the task, to the satisfaction of the Employer. The Contractor will be

required to submit to the Employer the Schedule of 'Manpower' and 'Organization Chart'. The contractor shall keep all the details, bio-data, photograph, references, application, and all such records with him even after he is removed or resigned from work of this site. Guilty person or indiscipline person shall not be employed by the Contractor.

3.3 The CV/Resumes of the Contractors personnel shall be submitted to the Employer for acceptance at least 7 days before the anticipated commencement of the O & M period. Any change of personnel shall be promptly informed to the Employer within a day's time. Normal time duty hours for the contractors' operation & maintenance personnel may be modified as necessary and agreed by the Employer. A rotating shift schedule shall be established by the Contractor and agreed by the Employer which will ensure that an adequate number of the Contractor's staff, fluent in Hindi as well as Gujarati is on duty at Plants 24 hours per day, 7 days per Week, including all holidays. The contractor shall have to issue **identity cards** with photographs to all the state employed for O & M. All the employees of contractor should be in specified **uniform indicating contractor logo**.

3.4 The Contractor shall submit a diagram showing the structure of the organization for his administration of the Contract. The structure shall include a Team consisting of Project / O&M Manager. The O&M Manager shall be stationed locally. The Project Manager shall have authority and powers to take decisions on the spot and/or incur expenditure(s) in the interest of the work whenever required by the Employer.

3.5 All correspondence and communication between the Employer and the Contractor including the Contractor's sub-contractors shall be directed through the Project Manager.

3.6 The sub-contractors proposed by the Contractor shall be subject to the approval of the Employer.

3.7 Contractor shall provide following minimum manpower as per qualification and experience mentioned below:

Sr. No.	Designation	Min. Qualification	Min. Experience	No. of Personnel
1	Laboratory Technician	B.Sc. (Micro / Chem.)	3 years experience for M.Sc. & 5 Years for B.Sc. and knowledge in identifying micro- organism and testing procedures	01
2	Plant Operator cum Fitter / Electrician	B.Sc. / ITI fitter / ITI (Elect. trade / Diploma (Mech/Elect)	3 years experience of operating pumping machinery / rotating eqpt.	04
3	Helper / Casual Labour	8th Std. Pass, Stout body Physique	Knowledge of Gujarati, Preferably experience of WTP/STP operation	08
			TOTAL PERSONNEL	**13**

Note: Security Guards shall be deployed by RMC during O&M period.

3.8 Minimum manpower required in various shifts is as follows:

Sr. No.	Designation	Nos.	Personnel per Shift			
			Gen.	Ist	IInd	IIIrd

			Shift	Shift	Shift	Shift
1	Laboratory Technician	1	1	-	-	-
2	Plant Operator cum Fitter / Electrician	4	1	1	1	1
3	Helper / Casual Labour	8	2	2	2	2
	TOTAL	**13**	**8**	**4**	**4**	**3**

Note:

- The staff as per above qualification and in specified numbers shall be deployed by contractor as a minimum at the time of commencement of O&M.
- Reliever not required for Lab. Technician position.
- The total no. of staff at Sr. 2 & 3 above is including reliever. Generally the staff in general shift to be adjusted as reliever and contractor to main minimum staff strength a specified in above table during all shifts. The shift schedule shall be submitted by contractor at least one week prior to start of month to client for review and approval and the staff shall be deployed round the clock as per shift schedule approved by client for each month.

3.9 Relaxation in qualification shall not be allowed. Relaxation in number of staff to be provided as a minimum as mentioned above shall not be allowed. The above / agreed staff shall be distributed in general and three shifts. General shift shall be considered as 09:00 Hrs to 18:00 Hrs. Preferable timing of shift shall be 06:00 Hrs to 14:30 Hrs, 14:00 Hrs to 22:30 Hrs and 22:00 Hrs to 06:30 Hrs (with half an hour of overlap).

The No. of staff in each shift should always remain present as per approved shift schedule by client; otherwise penalty towards absence of any staff shall be levied and recovered from the contractor as decided by Engineer-in-Charge of Client. Absence on any ground like weekly off or holiday shall not be considered. The presence of staff in each shift should be marked in register to be maintained at office of Engineer of the Client at Water Treatment Plant; which shall be considered as final. The contractor's staff must mark their presence & sign in this register. The contractor may maintain a separate register for his own purpose.

3.10 The staff of Contractor will always remain in contact with Employer and follow his instructions. The Contractor shall have to issue identity cards with photograph to all the staff employed for operation and maintenance; otherwise they will not be allowed to enter the plant premises.

3.11 The Contractor shall employ all the required staff (and in no case less than the number specified in the tender which is mandatory) within 7 days of award of the Contract, otherwise full payment will not be made. In such case, the commencement of the Contract Period and payment thereof shall be reckoned only from the date of employment of full numbers of staff. If at any stage it is felt necessary that additional manpower over and above the specified minimum manpower is required for the proper operation of the treatment plant, contractor shall employ necessary additional manpower at quoted rates within 7 days from the date of issue of notice by engineer-in-charge.
In addition to above **contractor shall arrange visit of their treatment plant expert once every 2-3 months** to study the plant and take stock of situation and provide his suggestions and guidance to O&M staff. He shall submit his visit report to client

including his observations for each month prior to or along with the monthly O&M bill submitted by contractor to client.

3.12 The Contractor will comply with all safety rules and regulations and all inter-disciplinary measures as followed by the Employer. The Employer will not be responsible for any accident / injury to the staff or any person of the Contractor or loss or damage to any property. Further, the Employer will not provide any insurance or free medical facility to the staff of Contractor.

Providing necessary security arrangement for safety of the plant and contractor's personnel will be the responsibility of contractor.

3.13 All Central / State Government / Semi-Government / Local Body's rules and regulation pertaining to this contract, all legal formalities pertaining to provident fund, factory act, all legal formalities shall be followed and observed by the Contractor without any extra cost to the Employer. Please note that failure in complying so, all liabilities arising as per laws will be to the Contractor's account.

3.14 No accommodation / guesthouse / transportation facility will be provided by the Employer to the Contractor. No staff or any person shall reside in the plant premises and any such person found shall be driven out immediately.

3.15 Due to strike by the Contractor's employees, the operation and maintenance of plant must not be affected and the property of CLIENT should not be damaged. In such case any dispute / discrepancy occurs, the decision of Engineer-in-Charge of client will be final and will be binding to the contractor. Also if any expense will be made by CLIENT, it will be deducted from Contractor's bill/ SD.

3.16 The duration of O&M contract shall be **02 (TWO) Years** from the date of issue of completion certificate / taking over certificate. However, client reserves the right to terminate the contract at any time by giving 3 months notice to the contractor.

3.17 Stacking / Storage (Alum / PAC, Chlorine & other chemicals) and day to day preparation of solution shall be arranged by the contractor. Disconnecting and removal of empty tonners and reconnection of filled tonners shall be carried-out by the contractor. All the required spares / consumables for disconnection/reconnection i.e. clamp/'O' rings/washers shall also be arranged by the contractor.

3.18 Plant shall be handed over on "**as is where is basis**" to contractor on the award of contract. Thus, the contractor has to takeover the plants for said contract without any insistence for any change in the plants.

3.19 The scope of work also includes **regular cleaning of complete plant area including floor, railing, door, windows, light fixtures and ceiling etc.** Similarly, minimum 3-5 mts. from the construction boundary on the outside of the plant area shall also be cleaned and maintained by the contractor.

3.20 This work is inclusive of but not limited to **operation, maintenance, house keeping, cleaning, removing sludge by its own carrier arrangement, painting, white colour washing, preparing data, recording, correspondence work to the client and**

Government Departments, etc. All this work should be done as per standard practices and by following labour, factory, electrical, and all other old and new law and order, Indian standards etc. as applied of Local, State and Central Govt. of India.

3.21 Nothing is to be provided by the client excluding electricity, raw water supply & chemicals mentioned above in these specifications. All the formalities to all government authorities for factory, electrical, etc. for having NOC, water consent, Hazard waste concern, approval etc. shall be done by the contractor. However, necessary legal fees to all government authorities shall be borne by the client.

3.22 Monitoring shall be done as per guidelines given by Engineer-in-charge. Contractor has to maintain all the parameters of treated water within the stipulated limits or he will be penalised for not maintaining the parameters given as per tender conditions. Penalty as decided by Engineer-in-Charge shall be deducted from his pending bills or Security Deposit.

3.23 The Contractor shall have to test the water samples of the raw and treated and from intermediate stage from each of the treatment units at every hour (i.e. 24 samples / day) through the laboratory provided at the plant; as per the schedule fixed by the Engineer in charge. The same have to be verified and checked by the Client once a week by taking parallel sample from the same point and at the same time and analysing the same at the client's laboratory. Proper register/record shall have to be maintained by the contractor and any modification /rectification, on the basis of analytical results of samples if required, in performance of each unit shall be carried out immediately. The daily analysis report along with steps for the rectification / modification taken, if any, shall also be reported to the client with the daily report. The weekly report shall also be submitted to the Engineer-in-Charge of the Client, with remarks and the steps taken for modification, if any, taken during the period of report.

3.24 No equipment shall remain idle or unrepaired or damaged or unutilized for the period exceeding 3-7 days and not exceeding 15 days in case of standby equipment (i.e. provided no. of working equipment as per design are available). If any equipment is not repaired, rectified and or replaced within specified duration, the contractor shall be penalised **with no limit at the rate of Rs. 1000/- per day of delay per each individual equipment of the plant.**

3.25 If a man on the duty remains absent and there will not be any reliever / replacement in his place i.e. if the contractor fails to depute no. of persons and of qualifications as specified in tender, the contractor will be penalised at the rate of Rs. 1000/- per man per day **upto no limit**.

3.26 The successful bidder shall have to enter into a contract agreement for O&M on successful completion of 3 Months satisfactory trial run, PGR and acceptance of plant and deposit an amount equal to 5% of total order value for O&M contract towards O&M security deposit.

3.27 The quoted rate shall remain firm and valid for entire specified duraiton of O&M contract.

3.28 The payment of O&M charges will be made as per Special Conditions of Contract for O&M.

For the entire O&M period, 10% amount from each monthly O&M Bill shall be retained.

All security deposits/retention money for O&M shall be released on successful completion of entire O&M period.

3.29 The other terms and conditions described in this tender documents, wherever applicable, shall remain unchanged.

3.30 However, **during O&M period, the contractor has to supply all the spares, at his cost during major-minor breakdown and also maintenance works.**

3.31 The penalty for various non-compliances due to reasons attributable to bidder shall be applied as under:

Sr. No.	Description	Penalty
1	Due to negligence or any such other reason of contractor's staff, raw water is not processed / treated in average quantity as per Client's demand (subject to availability of raw water and upto to maximum design capacity of WTP) & treated water quality to the tender requirements, in such a case penalty per case shall be recoverable from contractor.	Mini.Rs.25,000/- per case or higher as per tender
2	All the pumps & electro-mechanical equipment / machineries should be kept ready for operation. If it is not ready for operation more than no. days as specified in tender, than Client will deduct penalty from the bill.	Rs.1000/- per day / equipment
3	If the Contractor does not recruit/deploy the 'Personnel' identified as per the schedule or remain absent then Liquidated Damages will be deducted from the bill	Rs.1000/- per person/day for each case
4	It is Bidder's responsibility on daily basis for cleaning of pump house, sub-station room, transformer yard and compound of WTP, office, laboratory etc. from inside & outside. Removal of rain water from pump house, all buildings, sub-station and compound of WTP. If any it is not done than Penalty will be deducted from the contractor's bill.	Rs.1000/- Per case
5	Maintaining power factor as per tender and to avoid power factor penalty.	Rs.5000/- + If power factor penalty penalized by power supply company (PSC) monthly bill, than the same shall be deduced by RMC from the contractor's monthly bill if it is proved that the penalty is due to non-maintenance of specified minimum PF at proposed WTP.

4.0 MAINTENANCE

4.1 The maintenance service provided by the Contractor for the period specified in the Contract shall ensure the continuous operation of the Plant and that the breakdown or deterioration in performance, under normal operating conditions, of any items of Plant and equipment and component parts thereof is kept to a minimum.

4.2 The Contractor shall carry out the Maintenance of the plant installations in accordance with the requirements of the O & M Manual and also to the approved Maintenance Plan as mutually agreed.

4.3 The Contractor shall adhere to the manufacturers' recommendations with respect to equipment maintenance, the types and grades of lubricants to be used, frequency of lubrication, adjustments to be made regularly and keep in safe custody recommended spares, which may be required for smooth & trouble-free operation of the plant on day to day basis.

4.4 The Contractor to operate and maintain all equipment as recommended in the O & M manual and maintain logs and records of the work carried out to keep them in good working condition. The Employer shall approve the format of logs and records.

4.5 The Contractor shall prepare and implement an effective plant maintenance programmed in consultation with the Employer. It is absolutely the Contractor's responsibilities to look after all sorts of maintenance whether routine, preventive or break down or any other type of maintenance. The Contractor will be responsible to carry out day to day as well as periodic maintenance necessary to ensure smooth and efficient performance / running of all equipment.

4.6 The contractor shall the O & M Manual covering requirements for smooth & trouble-free operation & maintenance of the Plant.

4.7 Contractor shall set-up and maintain laboratory at plant site complete with all equipment, testing instruments, glassware, weigh scale, chemicals, reagents, consumables and carry out necessary calibration from time to time to conduct tests as required to check the water quality parameters (raw / intermediate stage / final treated) as specified in tender as a minimum.

5.0 DOCUMENTATION / REPORTS

5.1 The Contractor will be furnished with two copies of O & M manuals (prepared by him & approved by Employer). The Contractor will also be furnished with two copies of all instructions as may be issued by the Employer. One copy of all such O & M manuals and instructions issued to the Contractor shall be kept in his office at the site. The O & M manuals or instruction shall be considered valid only if the Employer has signed it. The Contractor will be responsible for keeping & updating record of documents including History Card for equipment and maintaining every day logbook. The Contractor shall maintain and update logbook and details of operational parameters like pumping hours, aerator operation hours, Amperes, Flow meter reading, H.T. Voltage (at power supply company / plant HT panel), Power Factor,

energy meter reading, pressure and other reading required are recorded in every shift at regular interval e.g. hourly or as agreed mutually (by CLIENT).

5.2 Computerized Printing of log sheets, registers and all necessary stationery required for maintaining records of operations and maintenances has to be arranged by the Contractor at his cost, duly approved by Employer. Format of log sheets, registers will be made available to the contractor by the CLIENT. All reports shall be in computerized format.

5.3. The Contractor shall submit to the Employer every week and within first seven days of every month, a copy of the weekly/ monthly O & M report. This report format and activity shall be as per O&M manual and as directed by engineer-in-charge from time to time. It shall also indicate the following:

Preventive maintenance work carried out during the month.

Preventive maintenance work that will likely to be carried out in the next week.

Maintenance carried out due to fault / breakdown of equipment.

The details of each equipment that was not available for operation due to preventive maintenance or breakdown of equipment related to that pump equipment, giving the reason for breakdown. The details shall include number of hours the pump equipment could not be operated and whether standby capacity was available and put into operation.

Details of parts and consumable replaced.

6.0 TELEPHONE FACILITY

6.1 The Contractor shall have to arrange for mobile telephone to two personnel of his Key Staff to be available at site from the start date of O&M. Any cost to the repair to the telephones and the telephone bills will be borne by the Contractor. Internet facility having broad band or suitable connection also to be provided till completion of O&M for ease of communication with employer during O&M.

7.0 SAFETY, HEALTH AND ENVIRONMENT

7.1 The Contractor shall be responsible for safety on Site during the O & M of the Works by the Contractor. Health of workers shall be protected against infectious and contagious diseases. Medical check-up at every six months shall be done. Environmental protection shall also be given priority so as to conserve the environment.

7.2 The Contractor's duties with respect to Safety shall include the following:

(a) Utilise safety awareness procedures in every element of operation and maintenance.

(b) Give emphasis to safety including:

i. Safe working and safety procedures as per rules and regulations of Department of Explosives, factory inspector, electrical inspector regarding use of protective clothing, gloves, boots and helmet etc.

ii. Cleanliness of the Plant as a whole
iii. Awareness of hazardous conditions and accident reporting and necessary compliance
iv. Safe practice in Treatment Plant

7.3 The Contractor shall be responsible for all safety measures and those procedures adopted shall comply with the Indian regulations pertaining to such work and local safety codes currently in force. Where such codes do not adequately cover the Plant then the Contractor shall ensure that proper safety procedures are followed. Those given below are minimum standards and the works shall not be limited to these, if higher standards prevails. The Contractor will comply with all safety rules and regulations and all interdisciplinary measures as followed by the Employer. The Employer will not be responsible for any accident/ injury to the staff of the Contractor. Further, the Employer will not provide any insurance or free medical facility to the staff of Contractor.

7.4 If the work in the vicinity of electrical equipment has to be carried out after connection has been made to the electricity supply the Contractor shall comply with any "Permit to Work" system approved by the Employer.

7.5 Suitable scaffolds shall be provided for workmen for all work that cannot safely be done from the ground, or from solid construction except such short period work as can be done safely from ladders. When a ladder is used an extra man shall be engaged for holding the ladder and if the ladder is used for carrying materials as well, suitable footholds and hand holes shall be provided on the ladder.

7.6 All necessary safety equipment as considered adequate by the Employer shall be available for use of persons employed on the Site and maintained in a condition suitable for immediate use. The Contractor shall take adequate steps to ensure proper use of the equipment by those concerned, in the following manner:

(a) Those engaged in handling any material which is injurious to eye shall be provided with protective goggles.
(b) Those engaged in welding shall be provided with welder's protective eye-shields.
(c) Those involved in works in areas where there is a risk of drowning shall be provided with life jackets.
(d) Electrician, wiremen and helper shall be provided with shock-proof shoes.

7.7 Adequate provision shall be made for prompt first aid treatment of all injuries likely to be sustained during the course of the work. When work is done near any place where there is risk of drowning, all necessary equipment shall be provided and kept ready for use and all necessary steps taken for the prompt rescue of any person in danger. Only after arranging such equipment, tools/ tackles etc. at site work shall be started.

7.8 To ensure effective enforcement of the rules and regulations relating to safety precautions, arrangements made by the Contractor shall be open to inspection by the Employer or his Representative and the inspecting officers.

7.9 Notwithstanding the provisions made above the Contractor is not exempted from the operation of any Act or rule in force.

8.0 TOOLS AND TEST EQUIPMENT

8.1 A complete set of necessary tools and test equipment required for operation & maintenance of the plant shall be available with the Contractor. This shall enable erection, dismantling, repairing, replacing or testing to be carried out on any part of the Plant whether of an electrical, mechanical or other nature, during the contract period. All tools and test equipment shall be procured, kept at site in good condition and used properly by the Contractor at his expense. The contractor shall prepare and implement an effective plant maintenance program in consultation with the Employer. It is absolutely the contractor's responsibilities to look after all sorts of maintenance whether routine, preventive or break down or any other type of maintenance. The Contractor will be responsible to carryout day to day as well as periodic maintenance necessary to ensure smooth and efficient performance/ running of all equipment.

9.0 INSURANCE CERTIFICATES

9.1 Within 14 days of the acceptance of this tender the Contractor shall produce to the Employer a certificate or certificates signed by the Contractor's insurers or their duly authorised agents covering all the persons with accidental policy of sufficient amount as per their grade (30 times monthly salary or higher as applicable as per statutory requirement) with disability benefit provision for them stating that insurance’s complying with the requirements of the contract have been effected. No such certificate shall relieve the Contractor of his obligations under the Conditions of Contract to produce to the Employer if required by him the insurance policies and the receipts for payment of premiums.

10.0 ASSISTANCE FOR THE EMPLOYER'S STAFF

10.1 The Contractor shall provide all necessary assistance to the Employer and his staff in carrying out their duties of checking setting out, inspecting and measuring the Works. The Contractor shall provide staff, office attendants, labourers and other help as may be needed from time to time by the Employer.

10.2 The Contractor shall provide for the Employer and his staff such protective clothing, safety helmets and rubber boots of suitable sizes, 440 volts series hand lamps and the like as may reasonably be required by them. These articles shall remain the property of the Contractor.

11.0 FIRST AID BOX

11.1 The Contractor shall at his own cost provide and maintain at the Site of Works standard first aid boxes at minimum six locations as directed and approved by the Employer for the use of his own as well as the Employer's staff on Site as stipulated by local regulations. Contractor shall arrange to train all their staff in first aid treatment within 3 months.

12.0 NOTICE BOARDS / DISPLAY BOARDS

12.1 The Contractor shall provide a Notice Boards/Display Boards at appropriate locations detailing precautions to be taken by operation and maintenance personnel in work in conformity with Industries and Labour Regulations and Department of Explosives.

13.0 APPLICATION

13.1 These general conditions of the contract shall apply to the extent that they are not superseded by provision in other parts of the contract.

14.0 GENERAL ROUTINE MAINTENANCE

To operate and maintain the water treatment plant and equipment in accordance with the aim and purpose of treatment. The plant and equipment covered under the above contract will be promptly attended by the contractor including any "Trouble shooting" to ensure smooth and trouble free operation. The contractor will be responsible for smooth and satisfactory operation and maintenance of the Water Treatment Plant on the round the clock basis for entire duration of O&M period from the date of taking over the plant after 3 months trial run period is completed and on acceptance of plant.

A Technical expert of the contractor shall visit the plant on every fortnight and will suggest if required, to improve the efficiency and working of the plant. The visit must be recorded at Employer's document and out come of the visit/ minutes of meeting should be got signed by Employer's authorized representative without which the visit shall not be considered.

The employer shall check the operation of the plant or designate an organization of his choice to carryout inspections. The employer or the organization appointed by him shall check that the Contractor is performing the tasks for which he is responsible with due diligence.

14.1 (1) Checking Alignment, tightening of fasteners, and lubrication of gear and other moving parts of various plant equipment / machineries.
(2) Checking of all pumps, motors, gears etc. for it’s proper operation.
(3) Observing/monitoring sludge quality / level in clariflocculator unit.
(4) Setting SV & Telescopic valve on sludge withdrawal line of clariflocculator to suit with the sludge consistency by sample analysis.
(5) Observing/monitoring the performance of filter beds.
(6) Checking all the pipelines for preventing choking, water tightness etc.
(7) Safe disposal of screening, sludge, etc. waste on daily basis.
(8) Watering of plants and trees

14.2 General routine maintenance schedule for various plant units shall be adopted from O&M Manual. However, the general routine maintenance to be carried out by the Contractor’s personnel will include but not limited to the following:

a) If it is observed that power consumption per MLD of water treated is increased, the contractor has to trace out the fault and rectify the same to bring to the standard Value.
b) De-weeding and cleaning of the Transformer yard and other places.

c) Checking and refilling of silica-gel in the breather of the transformer and checking temperature gauge, vent pipe, voltage tap changing switch
d) Regular watering in the earth-pits.
e) Check for any oil leak in the transformer and intimating and repairing of the same.
f) Opening of end cover & cleaning of dust by Air blowing of induction motors, PMCC and other panel & PCC
g) Checking and replacement of bulbs, tubes, chokes, starters, switches, control etc. throughout the plant and including outdoor lights and high mast pole installation.
h) Replacement of LT panel fuse base, links, fuse, relay, contactor kit (main and auxiliary) and timer.
i) Replacement of HT panel C/T or PT whenever required.
j) Check for any loose connection in electrical equipment and rectification of the same.
k) Monitoring power factor, take corrective steps and ensure optimum power consumption.
l) Replacement of gland packing for the pump, sluice valves etc. whenever required.
m) Greasing of bearings and lubricating all moving parts as per the schedule
n) Tightening of all loose nut-bolts and other fasteners
o) Cleaning of sump / tanks / reservoirs
p) Lubricating and test operation of the valves
q) General cleaning of all equipment and building
r) Replacement of pump rubber bush, gland packing, sleeve, bearing, oil seal, shaft, liquid ring and impeller.
s) Replacement of motor bearings and terminal plate and rewinding of motor when needed.
t) Replacement of non-return valve T bolt, hinge pin, flap/ gate.
u) Any other as required for proper operation of treatment plant facility

15.0 PREVENTIVE MAINTENANCE CHECKS

15.1 The Contractor shall adopt a preventive maintenance check's schedule as agreed mutually between the Contractor and the Employer.

15.2 The following checks as a minimum to be performed daily by the Contractor's personnel

a) Whether there is a change in the sound of a running pump, abrupt changes in bearing temperature and seal leakage?
b) The pump capacity, pressure, power consumption and vibration level to check if outage is required to address deterioration of specified performance values.
c) Rise in temperature of bearings in motor, in moving parts and other units, etc.
d) Working of gauges, sensors and other flow measuring devices
e) Average power factor, kVARH, kWH consumed

15.3 The following checks as a minimum to be performed weekly by the Contractor's personnel

a) Pipeline and valve leakage
b) Functioning of non-return valve
c) Tightness of all electrical connections of PMCC/MCC, APFC, ICP/LCP panel etc.
d) Tightness all cable connections

e) Temperature rise due to loose connections
f) Operation of valves and sluice gates.
g) Current and voltages in all electrical equipment
h) Average power factor, kVARH, kWH consumed

15.4 The following checks as a minimum to be performed monthly by the Contractor's personnel

a) Battery voltage, battery charger, topping of distilled water, tightness of terminations etc.
b) Gland packing
c) Wear and tear of moving parts
d) Adoption of Electrical energy conservation methods and energy consumption
e) Electrical contacts
f) Motors
g) Meggering of electrical equipment
i) Watering of earthing pits

15.5 The following checks as a minimum to be performed quarterly by the Contractor's personnel

a) Relay testing and calibration if possible of meters, gauges, instruments
b) Speed of motors
c) Level gauges and flow meters signals
d) Cleaning, checking/tightening of L.T. Circuit/Panel
e) Tightening of PMCC components
f) Auxiliary DB, Capacitor bank
g) Battery and Battery charger

15.6 The following checks as a minimum to be performed bi-annually by the Contractor's personnel

a) Free movement of stuffing box glands, gland bolts to be cleaned & lubricated and packing to be inspected to determine whether it requires replacement.
b) Pump and motor alignment should be checked and corrected if necessary.
c) Grease lubricated bearings should be checked to see that they contain the correct amount of grease and that it is still of suitable consistency.

15.7 The following checks as a minimum to be performed annually by the Contractor's personnel

a) Vibration should be reviewed. If the pump is tending towards unacceptable vibration levels:
i. The bearing should be removed, cleaned and examined for flaws and wear.
ii. The bearing housing should be carefully cleaned.
iii. Rolling element bearings should be examined for scratches and wear.
iv. Immediately after cleaning, rolling element bearings that are considered acceptable for reinstallation should be coated with grease. If the bearings are damaged it shall be replaced with new bearing of the correct size and type as per O&M manual.
b) Shaft sleeve and shaft should be examined for wear.

c) When coupling halves are disconnected for an alignment check, the vertical shaft movement of a pump with sleeve (journal) bearing should be checked at both ends with packing or seals removed. Any movement exceeding the original design clearance should be investigated to determine the cause. Endplay allowed by bearings should also be checked. If it exceeds that recommended by the manufacturer, the cause should be determined and corrected.

d) Stuffing boxes should be repacked and the pump & motor should be realigned and reconnected

e) Overhauling requirement of all equipment

f) Improvement required if any in operation of plant

g) Testing and Calibration of all instruments

h) Transformer cleaning, checking silica gel, oil checking filtering/replacing

15.8 **The scope also includes disposal of sludge generated within WTP premises at site identified by client within 10Km radius of the WTP premises**.

16.0 MINOR REPAIR GENERALLY ENCOUNTERED IN THE PLANT

16.1 The minor repairs which have been most often encountered are as given below:

Electrical works

a) For H.T. Installations
   i) Replacement of jumpers
   ii) Replacement of insulator (Porcelain)
   iii) Replacement of Air-Break Switch

b) For Both H.T. & L.T. Installations
   i) Replacement of no-volt coil for VCB
   ii) Replacement of Cable lugs including terminations
   iii) Replacement of burnt out HRC fuses
   iv) Replacement of moving and fixed contacts or contractors
   v) Repairs to isolators and switch fuse units and replacement of it and fuse base units.

Pump sets

a) Replacement of coupling bolt and nuts including rubber bushes

b) Replacement of worn out impeller nut

c) Replacement of spindle nut in the sluice valve.

d) Replacement of terminal plate in the motor

e) Replacement of faulty/dead spares in the battery charger and battery control panel.

f) Replacement of gland packing, graphite packing from the pump sets.

17.0 ADDITIONAL SCOPE OF WORK

17.1 For other incidental additional work, if any, the Contractor on authorization in writing from the Employer shall execute which is not specifically mentioned in the scope at present.

18.0 ELECTRIC POWER AND WATER

18.1 Client shall directly pay all the power bills but the Contractor will be required to furnish Electricity Consumption in the Schedules provided. If the average power factor in the electric (power) supply company bill is less than 0.95, the PENALTY /

CHARGE for the same as applicable plus Rs.5000/- shall be recovered from CONTRACTOR/THEIR BILL per occurrence of such incident.

19.0 PLANT INSPECTION AND VISITS

19.1 The Employer shall check the operation of the plant or designate an organisation of his choice to carry out inspections. The Employer or the organisation appointed by him shall check that the Contractor is performing the tasks for which he is responsible with due diligence. The Contractor shall at his cost provide all the assistance required by the Employer to complete these inspections.

19.2 Before any inspection, the Employer shall give prior notice of three days to the Contractor, indicating the name(s) of the person(s) empowered to carry out such inspection in the name of the Employer. In case of surprise visit, vigilance or other checks, such notice shall not be given.

19.3 At the end of each quarter period, or at the initiative of the Employer, a JOINT VISIT shall be organised so that both parties can check the condition of the installation at the plant.

19.4 A report shall be drawn up to record the suggestions and opinions of both parties. The Employer reserves the right to call in equipment manufacturers or specialised technicians for these visits.

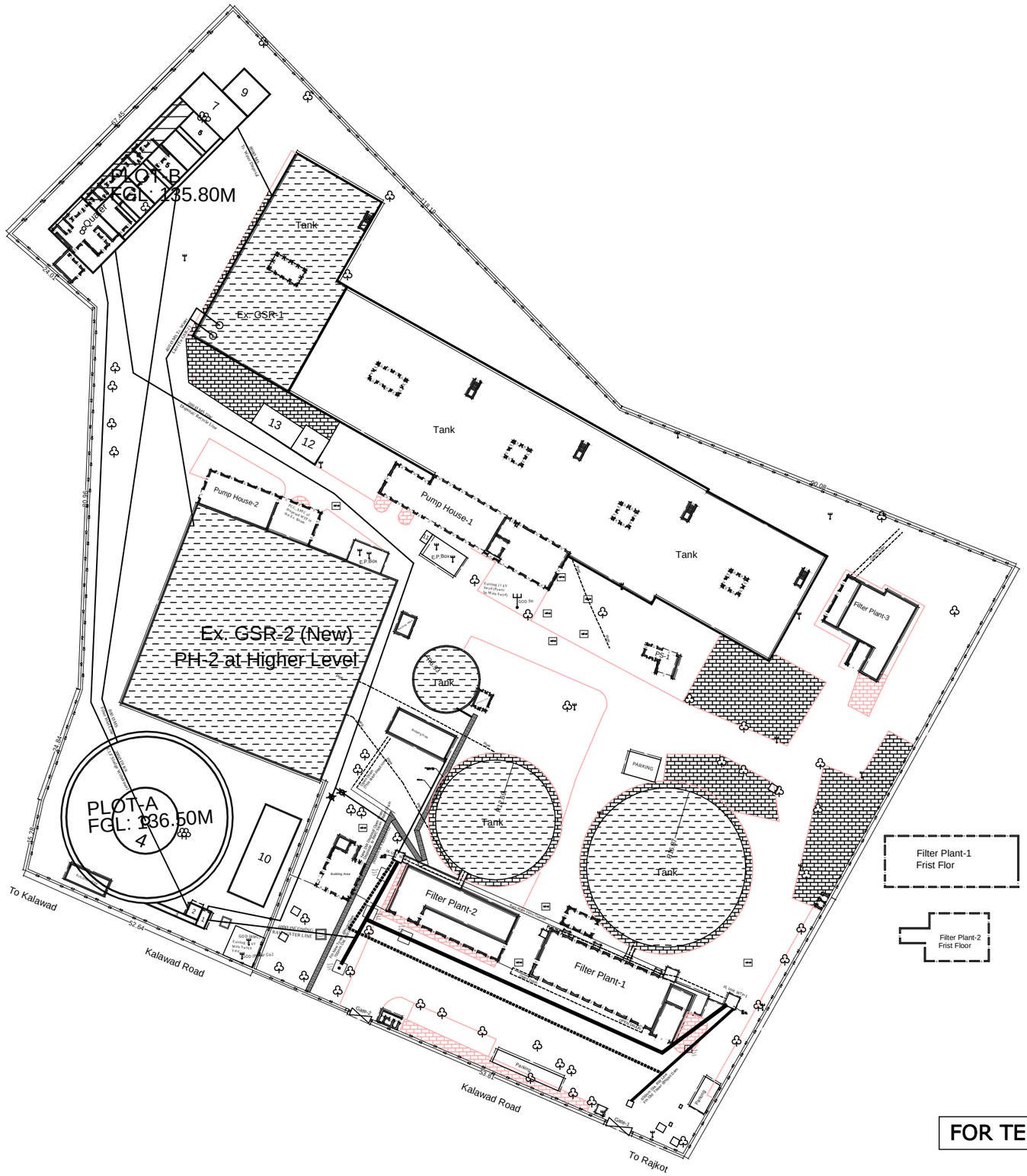
19.5 These visits shall provide an opportunity for examining maintenance programs and operating procedures and improvements requiring therein..

19.6 In addition to the above, the Employer reserves the right to arrange the visits of. VIP's dignitaries and other persons of Social or Political repute, as and when necessary, at the Treatment Plant. The Contractor shall offer full cooperation to the Employer on the occasions of such visits.

20.0 MEASUREMENT AND ANALYSIS

20.1 The Employer has the right to perform any analysis or inspection he deems necessary.

Drawings



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SCALE :- N.T.S

MINIMUM SIZE REQUIREMENTS TABLE

SR. NO.	DESCRIPTION	QTY.	SIZE (M x M x M)
1	INLET CHAMBER	1	1.8m x 3.7m x 3.10 LD
2	FLASH MIXER	1	2.6m x 2.6m x 3.00 LD
3	BYPASS CHANNEL	1	0.90M WIDE x 0.5M LD
4	CLARIFLOCCULATOR	1	34.0m ø X 4.0m SWD WITH INSIDE FLOCCULATION ZONE OF14mø X 4.0m LD
5	FILTER HOUSE	3 TWINS	7.8m X 4.2 m (EACH SECTION)
6	BACKWASH OVERHEAD TANK	1	290.00 M3
7	CL2 CONTACT TANK & PH CUM LT PANEL ROOM	1	CCT: 270 M3 PH: 90 M2
8	DIRTY WATER SUMP	1	13.0m x 9.5m x 2.50 LD
9	BLOWER ROOM	1	50 M2
10	ADMIN BUILDING & CHEM. HOUSE INCL LT ROOM(G+1)	1	160 SQM EACH FLOOR
11	REMOTEMONITORINGUNIT(RMU)	1	AS REQD
12	FOUR POLE STRUCTURE	1	36 m2
13	TRANSFORMER YARD	1	50 m2

NOTE :-
1. ALL DIMENSIONS ARE IN METRE.
2. 11KV FP STRUCTURE LOCATION SHALL BE FINALIZED BY ENGINEER- IN-CHARGE OF CLIENT.
3. OUTDOOR RMU LOCATION NEAR EXISTING PH-1 OR AS DIRECTED BY ENGINEER- IN-CHARGE OF CLIENT.

FOR TENDER PURPOSE ONLY

DATE	REV.	DESCRIPTION	DRAWN	CHECKED	APPROVED

CLIENT : RAJKOT MUNICIPAL CORPORATION

PROJECT: 25 MLD WATER TREATMENT PLANT AT NYARI

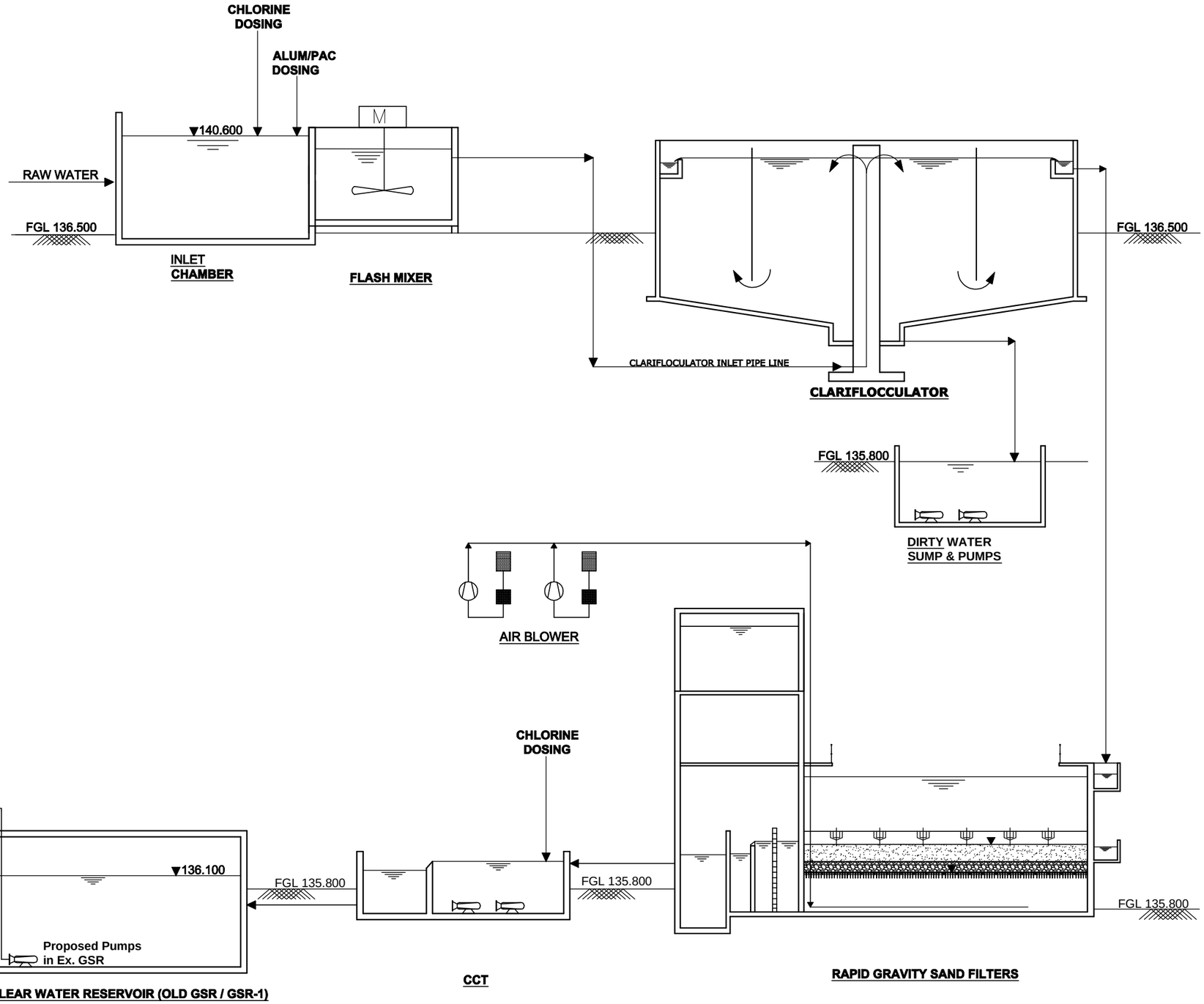
CONSULTANT :
SAPIENT TECHNO CONSULTANTS
701, REMBRANDT,OPP, ASSOCIATED PETROL PUMP,
C.G. ROAD, ELLISBRIDGE, AHMEDABAD - 380 006.
TEL :- +91 79 26422105, 4891323.
E-mail :- sapient_shs@sapient.net.in

DRAWN UNP
CHECKED SJS
APPROVED SHS
SCALE -
DATE : 26.09.23
REVISION R0

TITLE: LAYOUT PLAN

DRG. NO.:- STC/RMC/DPR/WTP-25/01

A3



PLOT A FGL: 136.50M
PLOT B FGL: 135.80M

FOR TENDER PURPOSE ONLY

DATE	REV.	DESCRIPTION	DRAWN	CHECKED	APPROVED

CLIENT : RAJKOT MUNICIPAL CORPORATION

PROJECT: 25 MLD WATER TREATMENT PLANT AT NYARI

CONSULTANT :
SAPIENT TECHNO CONSULTANTS
701, REMBRANDT,OPP. ASSOCIATED PETROL PUMP, C.G. ROAD, ELLISBRIDGE, AHMEDABAD - 380 006.
TEL :- +91 79 26422105, 48911323.
E-mail :- sapient_ahd@sapient.net.in

DRAWN UNP
CHECKED SJS
APPROVED SHS

TITLE: HYDRAULIC FLOW DIAGRAM

SCALE -

DRG. NO.:- STC/RMC/DPR/WTP-25/02

DATE : 26.09.23

REVISION R0

A3