



MUNICIPAL CORPORATION OF GREATER MUMBAI

STORM WATER DRAIN DEPARTMENT

INTERNATIONAL COMPETITIVE BIDDING (ICB)

BID DOCUMENT - _____

SPECIAL WORKS

PLANNING, DESIGN AND CONSTRUCTION INCLUDING SUPPLY, DELIVERY, ERECTION, COMMISSIONING OF MECHANICAL, ELECTRICAL, INSTRUMENTATION AND AUTOMATION WORKS FOLLOWED BY COMPREHENSIVE OPERATION AND MAINTENANCE OF MOGRA STORM WATER PUMPING STATION (SWPS) in K/W WARD

(Design, Build and Operate Contract)

VOLUME 2 DETAILED SCOPE OF WORK AND TECHNICAL SPECIFICATIONS

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Design, Build and Operate Contract

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Scope of Work

Section 2A – Detailed Scope of Work

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1. Background information

1.1 Mogra Nalla Catchment

This Mogra nalla system serves the catchment area between Andheri and Jogeshwari Railway Station and from Western hills (Malpa Dongri) to Versova. The system starts on the east of Western Express Highway, crosses the highway from south of Jeejamata Road and then follows Old Nagardas Road to cross Western Railway through Andheri Subway. After crossing Andheri Linking Road it runs through open marshy area and Lokhandwala Complex to discharge into Malad Creek.

There is considerable development after 1993 in this catchment, due to which there is considerable reduction in the permeable area.

Brief background of catchment area:

• Catchment No.	:	218 (In KE & KW Wards)
• Catchment Contributing Area	:	7.43 sq Km
• Total Drain/Nalla length	:	17.32 Km
• Type of drains	:	Open Nalla
• Width of drains (Nalla)	:	Varies from 1.5m to 51m
• Receiving Water Body	:	Malad Creek
• Invert Level at outfall	:	23.6m THD
• Design rainfall intensity	:	Twice in one year @ 55mm/hr for one hour

The proposed storm water pumping station at Mogra nalla outfall is to be designed for a storm flow of 42 m³/s.

2. General

The Scope of Works to be executed under this contract for, "Planning, Design, and Construction Including Procurement, Delivery, Erection, Commissioning, carrying out all Civil, Mechanical and Electrical, Instrumentation and Automation Works and Comprehensive Operation and Maintenance of Storm Water Pumping Station (SWPS) facility for a period of 7 years after successful commissioning in Mogra nalla, Mumbai shall include but not be limited to the following components:-

- 1) Surveys including topographic survey, bathymetric survey etc in connection with planning, siting of the works as necessary in the nalla stream, creek or over the land. It shall also cover utility survey whether above ground or underground likely to affect the proposed work and submission of detailed report.
- 2) Geotechnical investigations including onshore and offshore (in nalla/ creek portion) comprising of rotary boreholes, collection of disturbed and undisturbed soil and rock samples and preparation and submission of geotechnical appraisal report with recommendation for construction methodology and foundation design.

- 3) Designing and detailed engineering, hydraulic calculations, CFD analysis and hydraulic model studies
- 4) Foundation and structural designing for civil works, design and detailed engineering for mechanical works, electrical works, instrumentation works, PLC-SCADA and automation works as per design requirements and tender specifications including preparation and submission of general arrangement, working drawings and designs, design calculations, submission of drawing schedule and documents for entire Scope of Works.
- 5) Submission of General Arrangement drawings, technical specifications, design calculations, datasheets, catalogues etc. for mechanical, electrical and instrumentation works including equipment and accessories.
- 6) Execution of construction/ erection work shall begin only after approval of designs and drawings from Competent Authority /PMC consultant
- 7) Vetting of the designs, drawings and other submissions from IIT Bombay.
- 8) Desilting of the work site for full width of nalla bed from existing MCGM road bridge culvert up to 25m downstream of mitre gate structure. Dredging, excavation, and deepening to enable finished nalla bed/floor level of 21.0 m (THD). A nominal slope shall be provided on the nalla bed from existing MCGM road bridge towards proposed screen structure to facilitate accumulation of silt in the silt pit just upstream of roller gate and screens. Portion of nalla bed between screen structure and the pump structure shall be deepened further as per manufacturer's requirements, requirements of Hydraulic Institute Standards and to ensure smooth functioning and starting of the pumps at 23m. Slopes in nalla beds shall be achieved gradually adopting a slope not steeper than 1:8, unless specifically approved by Engineer due to site constraints / conditions. Cross-sectional drawings are provided in Section 2H, Volume 2 for Bidder's guidance with respect to indicative levels.
- 9) Construction of RCC retaining wall for nalla training from existing road bridge/ culvert upstream of screen structure upto 25m downstream of mitre gate / pump structure on both sides of the nalla. Section of the retaining wall from culvert to screens shall be constructed without any disturbance to mangroves. Retaining wall between screens & mitre gates shall create minimum disturbance to mangroves on either side of the nalla width. Similarly portion of wall downstream of mitre gates shall also be built with priority given to preservation of mangroves. Top of retaining wall shall not be at level less than 28m THD. Any branch watercourses shall be appropriately accommodated for and measures to ensure that mangroves are not affected or dry up due to the construction shall be taken.
- 10) Construction of civil structures of all units and all the ancillary structures as detailed in Volume-2, Section 2B – Technical specifications for Civil works, of this tender document and as approved by the Engineer. All units shall have proper access to roof. All buildings shall necessarily have minimum two exits.
- 11) Inspection at manufacturer's works, supply, erection / installation, testing &

commissioning of all the mechanical equipment as detailed in Volume-2, Section 2C-Technical Specifications for Mechanical works, of this tender document and as approved by the Engineer/ PMC consultant.

- 12) Inspection at manufacturer's works, supply, erection / installation, testing & commissioning of all the electrical & instrumentation equipment as detailed in Volume- 2, Section 2D – Technical Specifications for Electrical, Instrumentation and Automation Works, of this tender document and as approved by the Engineer/PMC consultant.
- 13) Obtaining necessary approvals, permissions, licenses from concerned authorities related to supply, construction, installation and commissioning of civil, mechanical and electrical, instrumentation and automation works.
- 14) Provision of all temporary access including removal after completion of the works. Construction of temporary structures, retaining elements such as sheet piles, cofferdams etc without obstructing the flow through existing nalla and flow diversion arrangements as required during the construction as necessary for unhindered flow of water (tidal or dry weather flow) in nalla as directed by the Engineer. Demolition of temporary structures, sheet piles and cofferdams, closure of temporary flow diversion arrangements at site, etc. or on completion of civil works in line with standard practices and reinstatement of site, as directed by the Engineer. It shall be noted that temporary enabling works may have to be demolished before any rains/ rainy season and reconstructed / reinstated back after the rain/ rainy season till completion of the works as directed by the Engineer. No extra payment shall be admissible on this account.
- 15) The ground water table, encountered during construction, shall have to be lowered sufficiently by the Contractor on continuous basis to enable construction in dry conditions. No separate payment shall be made for carrying out this work.
- 16) Transportation of excavated earth and disposal of screened material as per MCGM's debris management plan to any location within/beyond municipal limits, for which no separate payments will be made to the Contractor. Safe disposal of collected silt from nalla at designated place.
- 17) Preparation and submission of as-built drawings for the completed works including individual structures, equipment, accessories.
- 18) Carrying out and completion of trial runs and performance runs of individual equipment / accessories as well as that of the entire pumping system and commissioning of the entire pumping station as described in Volume 2, Section 2C, Section 2D and Section 2E of this tender document.
- 19) Preparation and submission of Operations and Maintenance Manuals for Storm Water Pumping Station at Mogra Nalla including O & M manual for individual equipment and accessories. Operation and maintenance of the pumping facility as broadly described in Volume 2, Section E – 'Operation and Maintenance' of this tender document.

- 20) Maintaining all site records in the formats approved by the Engineer and as directed by the Engineer during construction, trial runs, performance runs, commissioning and during seven years of operation and maintenance period of the pumping station.
- 21) Strict observance and adhering to all safety, quality and environmental requirements as per approved documents and as per norms as applicable and as directed by the Engineer.
- 22) All surplus and excavated earth and other debris including construction debris, deposits, large / small sized floating and suspended material collected from the silt pit and from area in front of the screen, removed screenings etc. shall be collected, removed and transported by the Contractor in accordance with MCGM's debris management plan. Contractor to note that no separate payment will be made for these works.
- 23) De-silting of Inlet bays, discharge bays, Mitre gate structure, Silt pit, Pump bays as and when required during construction, testing and Trial run period and its disposal in accordance with MCGM's debris management plan including transporting of silt. Contractor to note that no separate payment will be made for above works.
- 24) Obtaining NOC from concerned departments including fire department, obtaining permissions/approvals from Electrical Inspectorate, CCoE, MPCB, Civil environment department and other statutory bodies including approvals from Building proposal department, permissions required under factory act and all such permissions / approvals required for construction from competent authority.
- 25) Liaise with appropriate authorities for and obtaining LT connection from local area electrical supply company including laying of cables and provision and installation of metering system and also complying with other statutory provisions as required by the local Electrical supply authority. Cost of substation required, if any, for 415V supply shall be borne by the Contractor.
- 26) The period for planning, design, execution and completion of civil, mechanical, electrical and instrumentation works including their testing and trial runs and commissioning of the entire Storm Water Pumping Station facility i.e. 'Part A' of the Contract is 20 months excluding monsoon, from the date of Letter of Acceptance.
- 27) The period of comprehensive operation and Maintenance of the entire pumping station i.e. Part B of the Contract will be Seven years from successful start-up and commissioning and acceptance of performance guarantee of the pumping station i.e. after certification of successful completion of 'Part A' of the Contract.
- 28) During the Design Build period, including testing phase till the certification of successful completion of 'Part A' of the Contract, all charges pertaining to obtaining and using water, electricity, fuel, all consumables, replacements, spares, skilled manpower / specialists, inspection and testing etc. are to be borne by the Contractor. Similarly during the Operation and Maintenance period i.e. Part B of the Contract, charges pertaining to using water, electricity, all consumables, spares, diesel used for power generation and deployment of skilled manpower / specialist

etc. are to be borne by the Contractor during entire tenure of the Contract. All repair or replacement of parts or equipment, if needed, of whatever nature, minor or major, during start-up, commissioning and during the comprehensive operation and maintenance period including replenishment of spares shall be carried out by the Contractor at his own cost.

- 29) The storm flow carries excessive amount of silt, grit and fine suspended particles which tends to deposit, accumulate and form very stubborn mount if not cleaned and removed quickly/continuously. Silt trap are suggested to be provided in front of screens and pump bays with mechanically operated Grab bucket to clean the silt trap/pit and remove the deposits on continuous basis. In addition or alternatively bidders may propose any other effective system to remove the deposited silt / grit / suspended particles quickly / as soon as they get deposited, to avoid hardening of deposited material which quite often affects pump operation. Bidders shall submit details and write up of alternative system along with list of successful installations for scrutiny by Owner during bid evaluation.
- 30) Contractors are deemed to have visited the proposed site to acquaint themselves with the site conditions and their proposal shall take cognisance of all anticipated conditions whether explicitly mentioned in the Contract or not.
- 31) Provision of collateral warranties for key equipment viz. pumps, gates, DG sets from respective manufacturers.

3. Construction Design and Drawings / Documents

Reference Layout Plan, Sections of the pumping station and reference drawings are included in Section 2H, Volume 2 this Tender document for guidance purpose only. The design details and drawings provided in this tender document are for the purpose of reference only. The levels / elevation mentioned on the Bid documents / drawings may undergo minor changes during detailed engineering as per manufacturers requirements, CFD analysis, approval stage to suit site conditions, project requirements, engineering requirements. No extra claims shall be permitted on this account. These details including parameters and guidelines wherever given in this tender document shall be adopted by the Contractor for detailed design and engineering of the Storm Water Pumping Station. The Contractor shall design the Storm Water Pumping Station Facility in accordance with the specifications and best modern engineering practices. The preparation and submission of detailed design and working drawings for all Civil, Mechanical and Electrical-Instrumentation-Automation works including drawings of individual structure, equipment and accessories covering design requirements of the scope of works of the entire Storm Water Pumping Station shall be completed by the successful bidder within first two months (60 days) from the date of Letter of acceptance.

After the letter of acceptance, the Contractor shall carry out detailed hydraulic design, hydraulic analysis including CFD analysis and hydraulic model studies to finalise the details of entry to the pump bays and to finalise the pump sump details within the available plant space. CFD analysis and Hydraulic model studies shall be carried out under approved proven expert advice to find satisfactory flow pattern and satisfactory performance of the plant under all operating conditions. These studies shall be witnessed by the Client.

The Contractor shall design the Works such that the design life shall be a minimum of:

Item	Minimum Design Life (Years)
Civil engineering and building works (including underground services and pipes)	50
External pipe work and valves	50
Roads	25
Steel tanks and Support Frames	25
Mechanical - Internal pipe work and valves	25
Mechanical – Rotating machinery and complex equipment	15
Electrical – Cables	25
Electrical - HT Electrical, Transformers & Switchgear	20
Electrical - LT Electrical, Switchgear	15
Instrumentation, IT system	07
PLC and SCADA	07

All Plant, Materials, and equipment utilised in the Works shall be new.

3.1 CFD analysis

In case of CFD an unsteady, two-phase flow model shall be carried out. CFD simulation studies and hydraulic model studies of the sump shall be carried out to determine the following:

1. Predict the presence and location of the surface and submerged vortices and its frequency of occurrence.
2. The critical water level to avoid surface vortices.
3. Model anti-vortex devices as well as sump modifications for suppressing the vortices.
4. Model sump modifications including baffles to ensure equal flow distribution in each pump bay.
5. Model the effect of screen clogging on the flow rates and flow distribution.

The Contractor shall submit the results of CFD studies in the form of report with appropriate graphs and plots.

3.2 Hydraulic Model studies

The Hydraulic model testing will be carried out to ascertain that there is near equitable uniform, steady, single phase flow distribution to all the pumps in operation. As the availability of flow in the fore-bay will also be influenced by the clogging of the screen, the model studies should also study the effect of screen clogging. It should also identify the location of surface and sub-surface vortices and recommend remedial measures for the above. The effectiveness of the remedial measures should be proved through the model

studies.

The Hydraulic Model Studies and CFD analysis shall be demonstrated to MCGM's authorised representatives / PMC and got approved by IIT Bombay.

Following the hydraulic analysis, the Contractor shall carry out detailed engineering of the works including design calculations and drawings for submission and approval of the MCGM. The conclusions of hydraulic analysis and the pump General Arrangement (GA) drawing showing the details of pump bay entry and pump sump shall also be stamped and signed by the Pump manufacturer besides the stamp and signature of the Contractor.

The successful contractor shall submit 7 (seven) copies of design and drawings in accordance with the drawing schedule to the Engineer for his approval. Approval of Contractor's design in accordance with the Contract shall not relieve the Contractor of any of his obligations or liabilities under the Contract.

If changes in the submitted design/ drawings are required, the Engineer may request the contractor to resubmit the design / drawings after making the required amendments. The Contractor shall begin execution of works only after receiving the drawing approval from the Engineer. Contractor shall be responsible for preparation and submission of drawings and designs complete in all respects as per the requirements of the technical specifications and the scope of work and as per sound engineering practises. Non-compliance with this requirement may result in repeated revisions and resubmissions of drawings / designs resulting in time loss for which the Contractor shall be solely responsible.

The design philosophy, reference drawings, design specifications and parameters and guidelines are given in this tender document which will be followed by the Contractor while designing the Storm water Pumping Station Facility. In case, the Contractor proposes to change any of the details to suit his specific proposals / requirements within the confines of the performance requirements of the Storm Water Pumping Station, such changes will be studied and scrutinised during the evaluation process by the Engineer as long as the functionality is not adversely affected. Such changes may be rejected if the changes proposed are found not to be justifiable by the Engineer.

Indian standards or International standards have been specified in this tender document wherever required for defining an item or an engineering practice or a procedure. Works shall be carried out in accordance with relevant quality standards, test procedures or codes of practice. Use of any alternative relevant authoritative internationally recognised equivalent reference standard at no extra cost to MCGM may be permitted provided the Contractor submits copies of specified and relevant standards, proof of previous suitable use for review and assessment of the Engineer at the stage of approval of designs and drawings. However, Engineer's decision in this regard shall be final and binding on the Contractor

4. Site Information

The pumping facility / station is proposed to be located within the width of nalla/ creek without affecting any mangroves or environmentally sensitive areas (Please refer drawing no NJSEI/0197/MOG/LAY/001). Nalla width is broadly split in two parts. In one part, mitre gates

shall be installed whereas the other part shall be used for installation of horizontal / inclined / vertical mounted axial flow pumps and necessary gate arrangement.

Facilities like Administration cum Electrical operation building, Diesel Generating sets, DG set Chimneys, Diesel Storage tank, Water storage tank, security guard room, Fire-fighting tank and system, Sewage collection tank etc. shall be located on a platform to be constructed at a height above nalla bed. The soffit of this platform shall not be lower than 28.5 m THD.

Elevated approach road, clear 7.5m wide from existing MCGM road bridge connecting to above platform shall be included in scope of this work. The approach road shall be provided with 1.2 m high crash barrier wall on both sides. The road shall have two entry gates – one at the MCGM bridge end and other near the screens at SWPS end. The bridge end gate shall be 2.2 m high heavy duty and motor operated remotely from the security cabin located inside the SWPS gate. The bridge end gate shall also have a remote CCTV camera feeding monitor in Security cabin. The SWPS platform shall have surveillance system with several CCTVs as defined in detailed specifications.

The approach road and the road on the platform shall be designed for AA class of IRC loading.

It shall be the responsibility of the Contractor to obtain all applicable permissions for working on this site.

Current access to site is only through the nalla.

High tension (33 kV) overhead electrical transmission lines are passing over the proposed site. Co-ordination with concerned agencies for shifting/re-routing these lines as required to clear the pumping station installation is in Contractor's scope.

5. Pump Capacity and Pumping station design

The specifications provided under Volume 2 (Section 2A to 2G) of this Tender document are only for guidance for the design of the pumping station and for selection of equipment. The type of pumps to be considered for Mogra Storm Water Pumping Station shall be horizontal / inclined / vertical mounted axial flow pumps.

For selection of pumps, the design and performance of the pumping station shall adequately serve the objective / purpose of setting up the facility and the performance shall be equivalent for both types of pumps.

The pump design shall facilitate flows from upstream side to downstream side of pump without compromising on the cross-sectional area of the pump channel.

The hydraulic design of the facility shall be done as per recommendations of latest Hydraulic Institute Standards. It is also to be noted that in non-monsoon season the nalla carries wastewater also, whereas in monsoon it carries mixture of storm water and wastewater. The flow carries very high amount of silt, grit, floating and settled materials of all kinds. In the system design these aspects shall be taken into consideration.

After completion of the design-build period and within the defect liability period, if it is observed that the pumping station cannot deliver intended result due to any unforeseen circumstances, MCGM reserves the right to ask the Contractor to make necessary amends and design changes at any stage without any additional financial liability to MCGM. The cost of all such additional equipment / accessories required for achieving the desired result shall be borne by the Contractor.

Seven pumps (all working) shall be provided each having individual capacity of 6 m³/second when pumping against a total head of 6 metres. Tenderers are advised to confirm the pump capacity and also verify and confirm the selected head over the pump considering governing levels, static head and dynamic head losses in the pumping station. The design of pumps and the pumping station arrangement should be such that combined flow of all 7 pumps when running simultaneously and measured in individual pump channel shall in no case be less than 42 m³/sec at available static head at site. Use of velocity flow meters or any other hydraulic/mechanical flow measurement device to suit the site conditions shall be used to provide correct flow measurement.

Due to available space for construction of the Pumping Station, the sizing and hydraulics of the Pumping station is critical and must be given due consideration while designing the facilities. Specifically, vortex free and cavitation free operation of the pumps are of prime importance and the proposal shall take this aspect in to account.

It shall be noted that the storm water to be pumped also carries sewage / effluent from the catchment area and sea water. Further, the pumping station and its components shall be subject to severe environmental conditions like exposure to marine environment, natural tides and wave action, exposure to brackish and saline water, alternate drying and wetting, abrasion due to floating and suspended material etc. While designing the pumping station and selecting the material of construction of different components, the tenderers shall take into consideration the above factors.

The scope of work shall include provision adequate safety measures during DB as well and O&M parts of the contract and shall ensure security of their works, both these stages of the Contract.

6. Hydraulic Particulars and Controls

The Mogra nalla carries storm water drainage from a large area of the catchment area. During high tide, flow through drain will be restricted by the tide and tidal gates are to be installed to prevent tidal water entering the drain and pumping station. The pumping station is to be designed to pump flow during rising tide conditions when gravity discharge of sufficient quantity is restricted.

The tidal control (Mitre) gates should be designed to operate automatically to open and close depending upon tide and flow conditions and will also have provision for manual operation. During flood situation, when low tide conditions are there, the tidal control gates shall remain open and the flood water is expected to pass through the drain through the gate into the sea. However, during rising tide conditions the flood control gates will be closed and the flood water is expected to enter the proposed storm water pumping station. The flood water shall then be pumped downstream of Mitre gates towards sea.

Under the current project, the Contractor shall provide level sensors upstream and downstream of the gates which shall be used to provide audible and visual warnings to the operating staff when levels downstream are higher than those upstream indicating that the gates should be closed; and when the levels are higher upstream than downstream indicating that it may be appropriate to open the gates.

When the gates are closed during high tide, the pumps should operate automatically based on level controls in the pump bay with an option for manual operation. A programmable logic controller (PLC) shall be provided for pump operation and sequencing the operation of individual pumps. At any time, the difference between total operating hours between any two pumps shall not be more than three hours.

In order to prevent backflow into the pumping station at extreme tides the downstream end of the pump bay shall be provided with flap valve. Main levels controlling the hydraulics of the pumping station are:

	m THD
Design low tide	21.95
Maximum tide level	27.5
Sill level at the mitre gates	To be decided based on actual level at site ensuring that the entire flow from nalla upstream passes through mitre gates by gravity when gates are open and tidal backflow effect is not there.
Maximum Water level to be maintained at the inlet bay	25.00 m or as directed by MCGM Plant In charge
Highest water level at which first pump should start operation	23.00m

Pump controls should be arranged to ensure that, the water level in the inlet bay just upstream of the isolation gates should be maintained as above.

Water level to be maintained in the inlet bay upstream of the isolation gates may be changed by the MCGM Plant In charge during the course of operation and maintenance to meet the changing situations / demands of the catchment. When required such changes and the applicable period shall be intimated by the MCGM Plant In charge to the Contractor in advance. During such period the operation of the pumping station shall be carried out as per intimated revised level to be maintained in the inlet bay, just upstream of isolation gates.

7. Scope of Civil Works

Main components of civil works for Storm Water Pumping Station at Mogra are as follows:

- a) Silt pit /trap upstream of trash racks.
- b) Stop logs immediately after silt pit upstream of trash racks to facilitate isolation of trash racks & screens for periodic maintenance.
- c) Pump structure comprising of separate bays for each pump sized and configured to meet hydraulic requirement of the pumps including isolation gates and arrangement for its lifting and removal, , Pump Mounting structure, Overflow weirs(*), Discharge channels(*), Discharge bay, Flow kickers(*), Wave breakers(*), etc. Note :- (*) If applicable.
- d) EOT or hoists as per required safe capacities as necessary for the proposed facility shall be provided during installation and maintenance, mounting arrangement for soft starters, Gratings to cover openings, Cable tray mounting arrangement
- e) Platform foundations for D.G. sets with acoustic enclosures and exhaust arrangements and Electrical panel building to house NGR panels, Cable and Cable trays etc. complete, Bulk Diesel Storage facility, Day tanks with shed, Fuel transfer systems, Main electrical room to house HT and LT switchgear, PLC SCADA control room, and office for Operations and electrical and instrumentation staff, Conference room as per tender specifications. Shed to be provided for the day tank shall ensure that no rainwater enters the tank either directly or through air drift from the sides.
- f) Painting / Coating as specified of all the units including internal surfaces of water retaining structures and external surfaces of all structures below ground in contact with earth wherever required, as specified in Volume 2, Section 2B – Civil Specifications.
- g) Providing and constructing Water supply network, potable water Storage tanks including Water appurtenances, sanitary works. Rainwater from site shall be disposed to nalla down stream of mitre gate. All sanitary wastewater will be collected in a RCC tank and shall be pumped to approved MCGM sewer network using non clog submersible sewage pumps (1W+1SB) through K9 DI pipeline.
- h) Various other equipment and Foundations and support structure for DG stacks as specified in section 2B and 2C.
- i) Providing and building Firefighting network, Fire-fighting pump room, Fire water storage tank having adequate holding capacity to meet TAC and other statutory requirements and services as specified in section 2B and 2C and as approved by the Chief Fire officer, MCGM. All fire safety requirements and fuel storage and handling requirements shall be duly complied with.
- j) Providing and installing pressurised water jet arrangement (min pressure of 3-4 kg/cm² at the stand points) for Screen area and Pump area including construction of storage tank, distribution piping up to stand points, quick release couplings, flexible hoses, valves, pumps etc. as required complete. Storage tank for pressurized water jet arrangement shall be above ground and capacity provided shall be as per pump manufacturer's recommendation.

- k) Providing solar panels on rooftop of electrical-cum-administration building to maximise solar energy harvesting. The solar energy generated by photo voltaic system during daytime will be stored in adequately rated (AH) lead acid batteries and shall be utilised, with an appropriately rated inverter, for outdoor and indoor lighting during night-time and air-conditioning during daytime. Switching ON of all lighting from grid supply to solar supply will be automatic with manual over-ride facility. The nos. of solar panels shall be such that the lighting and air conditioning loads are completely taken care of during fair season.
- l) De-silting of Mitre gate structure, Silt pit, Pump bays as and when required during construction, testing and Trial run period and its disposal in accordance with MCGM's debris management plan including transporting of silt. Contractor to note that no separate payment will be made for above works.
- m) Providing and installing Honeycomb gratings (hot dipped galvanized) to cover openings on platform, pump area, Electrical room and Inlet area, Screen area and Mitre gate area as per approved G.A. drawings
- n) Providing and installing hand railings (SS316) with toe guard wherever necessary as per approved G.A. drawings.

8. Scope of Mechanical, Electrical and Instrumentation works

Scope of Mechanical Works are covered under Volume 2 Section 2C - Mechanical Specifications and scope of Electrical, Instrumentation and Automation works are covered under Volume 2 Section 2D – Electrical Specifications of this tender document.

9. List of Drawings

The List of Reference Drawings being provided with the bid documents for reference is as follows:

Sr. No	Drawing Title	Drawing No.
1	Reference Layout of Mogra Storm Water Pumping Station	NJSEI/0197/MOG/LAY/001
2	Reference Plan of Mogra Storm Water Pumping Station	NJSEI/0197/MOG/GAD/001
3	Reference Cross Section of Mogra Storm Water Pumping Station	NJSEI/0197/MOG/GAD/002
4	Reference Single Line diagram for Power Distribution System	NJSEI/0197/MOG/SLD/001

10. Concrete Structures

All water retaining civil structures and civil structures coming into contact with storm water shall be designed on no-crack basis using M40 design mix concrete. Ready mix concrete shall be sourced from MCGM approved RMC plant. Concrete surfaces shall be fine faced shuttered or steel trowel finished as appropriate on all exposed surface. Rendering of surfaces will not be permitted.

The structures shall be designed considering ground water saturation upto Finished Ground Level.

For further details refer Volume 2, Section 2B of this tender document.

11. Screen area, Pump bay and Mitre gate area

A screen structure to accommodate screens covering entire width of the nalla bound by retaining walls shall be constructed parallel to and near the SWPS platform. This structure shall facilitate installation of screens for the purpose of arresting and removal of screenings from the storm water flowing to the pump bays during pumping operation. The storm water will bring along large and small sized floating as well as suspended materials, debris, rags, plastics and bottles, dead animal bodies, tree branches etc. which shall be removed from screen face. The screen and screen structure shall permit smooth and adequate flow of storm water, without blockages, to reach the pump bays. The screen structure shall facilitate easy removal and installation of screens in their positions.

The pumping structure platform will provide access to the screens and mechanical screen cleaning mechanism for installation, operation and maintenance purposes. The platform shall also accommodate bins of adequate size or belt conveyor for collection of removed screenings from the screen face for disposal.

Other details related to the screens and positive raking type mechanical screen cleaning arrangement are described under Section 2C, Volume 2 of this tender document.

A silt pit of minimum 1.5m depth shall be provided in front of screens along the entire length of the screen structure i.e. entire width of the nalla upstream of the screens to facilitate retention, collection and removal of silt and large and small sized floating as well as suspended materials, debris, rags, plastics and bottles, dead animal bodies, tree branches and such deposits.

Between silt pit and each Mechanical screen two nos. J-type trash rakes (one installed and one store standby) in SS316 construction shall be provided.

An electrically operated overhead travelling gantry crane / EOT crane of minimum SWL capacity twice the max weight of equipment / component to be lifted shall be installed atop the screens. The Gantry crane / EOT crane will have longitudinal/cross movement to cover entire area for handling Grab bucket, J type trash rakes, Mechanical Screens, and Stop logs in front of Screens. This Gantry / EOT shall have provision of grab designed for removal of large and small sized floating as well as suspended materials, debris, rags, plastics and bottles, dead animal bodies, tree branches and such deposits from the silt pit. This Gantry / EOT crane shall facilitate collection and disposal of removed screenings up to

the disposal point inside plot boundary.

Tidal control gates (Mitre gates) will be located adjacent to pump bay at the downstream end towards seaside. These tidal control gates when closed will arrest the tidal effect from reaching the upstream side during rising tides / high tides. During low tide conditions, the tidal control gates (Mitre gates) will be opened for allowing gravity discharge of storm water into the sea. An electrically operated overhead travelling gantry crane / EOT crane for handling mitre gates / stop logs / super structure of mitre gate of minimum SWL capacity twice the max weight of equipment / component to be lifted whichever is higher.

Stoppers shall be provided on Gantry rails / EOT girders to limit longitudinal as well as cross movement.

Platforms covered with honeycomb gratings (hot dipped galvanised) and fitted with hand-railings shall be provided at suitable locations to facilitate handling of Mitre gates, Stop logs, Screens and sluice gates during installation / removal as well as to facilitate personnel movements during operation and maintenance.

Also, disposal of removed material, solid waste, debris etc. shall be the responsibility of the Contractor as per MCGM's debris management plan. No separate / additional payment to the Contractor shall be admissible on this account. It shall be Contractor's responsibility to ensure frequency of cleaning of silt trap on regular basis to prevent piling of silt deposit and to prevent putrefaction septicity of deposited material in and around silt trap.

Level sensors shall be mounted on upstream side and downstream side of Mitre gates for continuous monitoring of Storm water levels and tide levels.

12. Pump Bays

Each pump will be housed in a discrete bay which will be sized and configured in accordance with the pump manufacturer's requirements. The design of individual pump bay should be such that incoming flow smoothly reaches the pump without any hydraulic losses when all 7 pumps are running simultaneously to deliver cumulative flow not less than 42 m³/sec at any given differential head condition at site.

Isolation gate will be provided at the entrance to each bay for isolation of the pump bays individually. Flap gate and isolation gate shall also be provided on the downstream side of each pump bay.

The pump mounting and discharge arrangement shall be as per pump manufacturer's requirement approved by the Engineer.

The pumping structure shall be provided with a superstructure as indicated on the conceptual section with provision of electrically operated actuators shall be provided for operation (lifting and lowering) of pumps, roller gates. EOT crane shall be provided for operation of grab buckets and stop logs.

13. D.G. Platform

The D.G. platform shall be designed and constructed to house the following:-

- Main HT Diesel Generating sets (min 4 sets) of required power generation capacity as described in the tender specifications and as per design requirements of the Storm Water Pumping Station, DG set Foundations, DG acoustic enclosures, DG Control panels
 - Cable trays / cellars for power and control cables
- D.G. platforms shall be provided with support structure for stack arrangement of all the DG set.
- Main diesel storage tank of required capacity shall be installed in RCC structure with appropriate lining suitable for diesel storage placed over the SWPS platform. Fuel transfer pumps and fuel transfer system with piping and valves etc. shall be located and installed outside D.G. platform as per approved layout by the CCoE and as per required design. All these provisions will be part of D.G. platform.

14. Main Electrical and Operation House and Administrative Office

The building shall be designed and constructed to house the following:-

- NGR and NIS panels of approved design for Main DG sets
 - Day tanks of specified capacity, Fuel transfer system and Control panels as per design requirements
 - Auxiliary LT D.G. sets of required rating for emergency power supply with acoustic enclosure
 - Transformer of 250 kVA
 - One metering room for receiving external LT power supply
 - Firefighting system as per approval of the fire officer
 - Hot air exhaust arrangement for transferring hot air from D.G. sets outside the building
 - Cable trays / cellar for power and control cables
 - HT Switchgear panels including spare panels for all the pumps and DG sets including Auto-synchronization panels
 - PLC SCADA panel room including for Operation and Control of the entire pumping Facility, Air conditioners for PLC-SCADA room
 - LT switchgear for Pump and DG, APFC panel and ACDBs
 - Room for Battery and battery charger
 - Two engineering offices for Operations and Maintenance staff, One conference room, one storeroom each for Electrical and Instrumentation - automation works and one record room as per approved layout
 - Telephone and intercom facility, Alarm system
 - Firefighting system as per approval of the fire officer
 - Separate staircase for Emergency exit
 - One toilet block consisting of 3 urinals, 2 (One European and one Asian) toilets, two wash basins with mirrors.
- Elevator (Lift) with collapsible gate for access to second and third floor

The administration office shall be located on the third floor of Main Electrical and Operation

House. The admin office shall accommodate office rooms for engineers, conference room, pantry and toilet etc. The total area of this floor shall be approx. 300 Sq. m.

The buildings shall be RCC framed structure with brick walls & RCC roof slab. The internal lighting, internal water supply & sanitation and joinery shall be in accordance with the specifications.

Other building specifications (flooring, doors, windows, rolling shutters, plastering, painting etc.) shall be in accordance with the detailed specifications given in Volume 2, Section 2B of the tender document.

One 5 KL capacity RCC tank shall be constructed at the top of the building and one RCC water tank of 5 KL capacity shall be constructed adjacent to the building on the platform. All the internal potable water supply services network shall be connected to the overhead tank. Transfer of water from platform level tank to overhead tank shall be done using 1W+1SB submersible SS pumps. The platform level tank shall receive municipal water connection.

There shall be sufficient room between and around plant and equipment to move around freely and to facilitate repair and maintenance considering the health, safety and environmental factors.

A network of electrical cable trench / Cable trays shall be provided to house the power and control cables connecting the various panels & equipment.

Before commencing the construction of the building, the contractor shall submit to the approval of the Engineer drawings of the proposed building with all architectural and finishing details fully shown. The architectural view of the building shall be prepared, submitted and got approved from MCGM approved architect. All the architectural rendering shall be as per MCGM requirements.

Toilets shall be provided on each floor. Adequate number of toilets and wash basins shall be provided separately for men and women.

Following furniture shall be provided in the office:

- Two wooden conference table 3m x 1.5m with twelve revolving chairs.
- 5 nos. 1.5m x 0.9m tables with both side drawers.
- 5 nos. 1.2m x 0.6m tables with one side three drawers.
- 20nos. revolving chairs
- One no. six-seater sofa
- Chairs for computers
- 5nos. steel cupboards (storewell or any other approved make)
- 3nos. filling cabinets with 4 drawers.
- Vertical blinds to all windows
- Water supply, sanitary arrangements (toilets/ bath) plumbing (including disposal line up to the nearest municipal sewer (with vacuum sewer arrangement or any other arrangement as directed), electric supply with lights and fittings as directed etc complete
- Telephone with STD facility
- Ceiling fans

- The fittings shall include:
- AC units for Conference room and two other rooms for Engineers.
- 4'-0' long tube lights in each room except in conference room and toilet (1 no. per 3 sq.m. floor area)
- 6 tube lights 4'-0' long in conference room
- 2 nos. ceiling fans in conference room
- All rooms with 4 nos. plug points each
- Passage 4" long tube light at every 20" distance

The Office shall also be provided with the following:

Sr.	Item of Work	Work
1	Personal Computer	02 No.: minimum Core i7 9 th Generation processor, 1 TB Solid State Disk Storage, 8 GB RAM, DVD writer, 22" HD flat Screen Monitor, 6 USB Ports, MS Windows 10 or later, MS Office license for the duration of the Contract, Webcam, Speaker System etc. as directed by the Engineer
2	Laptop	1 no. 14" screen size, minimum Core i7 9 th Generation processor, 512 Gb Solid State Disk Storage, 8 GB RAM, 2 USB Ports, MS Windows 10 or later, MS Office license for the duration of the Contract
3	Printer	1no. All in one- A3 size Inkjet (Multifunction Printer, scanner, Fax, Copier). 1no. A4 size Multifunction Mono Laser Printer with Printer, scanner, Fax, Copier
4	Telecommunication Facility with EPABX	Configured for min. two nos. telephone line with a broad band connection and 15 Extensions with following facilities shall be provided: 3-Level Automatic Reception with Voice Guidance, Built-in Voice Message, Caller ID, Uniform call distribution, Call forwarding, 5 – Party Conference, Calling activity report, SMDR paging, Call pickup The operation and maintenance cost of above facility for the entire duration of construction including O & M period shall be borne by the Contractor.
5	Glow sign board on top of Admin Building	One no. glow sign board of min. size 20' x 5' shall be provided which should include name of SWPS, name of employer as directed by the Engineer-in-Charge
6	Tools & equipment	Megger (1kV), multi-meter, hard hat (4 nos.), safety shoes (4 nos.), earthing rod, torch, Portable Emergency Rechargeable etc.

The operating and maintenance expenses for the office throughout the O & M period of the contract shall be borne by the Contractor.

15. Gangways, Platforms Ladders, Stairs and Railings

All of the equipment, operating platforms, instruments, panels etc. shall be provided with Volume 2, Section 2A

Detailed Scope of Work

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access. An RCC staircase / fabricated staircase / SS316 Caged ladder as per approved drawings shall be provided to access all the platforms provided for all the units above and below ground level. For staircase the tread width shall be 250 mm and c/c spacing between two consecutive treads shall be 175 mm maximum. The minimum clear width of staircase shall be 1.2 m.

SS316 railings shall be provided along all the working and access platforms above the floor or ground level, and where clear openings are provided. The minimum width of all working/ access platform shall be 1.2 m. The railings shall be made as per approved drawings.

Other details are specified in Volume 2, Section 2B- Civil specifications

16. Electrical Lighting Requirements of Buildings & Pump Houses

The Contractor shall execute all works related to the provision of internal and external electrical lighting requirements of the Pump house, D.G. platform, Electrical Building and other buildings / structures as per approved layout plan.

The contractor shall provide all indoor and outdoor lighting fixtures complete with lamps, ceiling & exhaust fans complete with speed controlling device, receptacles, fuses, lighting panels for each unit, street light poles and all other miscellaneous works required to fulfil the lighting requirements of buildings and the surrounding area.

Detailed specifications of various items for electrical lighting requirement is given in Volume 2, Section 2D – Electrical and Instrumentation Specifications.

17. Safety provisions and Quality assurance plan

All safety provisions as per General Conditions of the Contractor for Civil works, MCGM Mumbai latest edition, shall be strictly followed by the Contractor.

18. Lowering of Ground Water Table

The ground water table, encountered during construction, shall have to be lowered

sufficiently by the Contractor on continuous basis so as to enable construction in dry conditions. No separate payment shall be made for carrying out this work

19. Roads, Pavements & Surface water Drainage

This shall include the construction of RCC kerb and channels, CC road – M40. Adequate longitudinal and cross gradients shall be provided in the kerb, channel and roads for the proper drainage of storm water.

The roads shall be as indicated in the Conceptual Layout, modified as necessary to ensure that vehicular access, adequate for the delivery and removal of installed plant and equipment, is provided to all buildings. These roads shall have a minimum width of 6m CC road surface in accordance with the specifications and as directed by the Engineer.

20. Water supply network & fire-fighting system

Internal water supply & fire-fighting system will include, connection to the on-site water supply, laying of water distribution network (including water appurtenances like sluice valve, scour valve, fire hydrant, air valve, non-return valve etc.) connecting all the overhead/ underground water tanks and additional connection points with valves for gardening, cleaning purpose.

Pipe network laid shall be of uPVC of pressure class 10 kg/cm² as per IS codes. The minimum diameter of the network pipe & service connection pipe shall be of 90mm OD, PVC & 25 mm ID G.I. (medium class) respectively. Fire hydrants shall be provided near all the units of buildings/ pump houses/ panel rooms in accordance with the directions of Engineer.

Fire-fighting system shall be as per MCGM's Fire department norms. Service water storage and connection shall be as per MCGM's HE department norms.

21. Painting, Whitewashing and Allied Works

Interior / exterior surfaces of all the units/items/equipment/ structures of the buildings/ pump houses shall be painted / coated as specified in Volume 2, Section 2B and Section 2C of the tender document.

22. Sewerage System

Sewerage system to cater to the working staff at the establishment shall be provided with proper arrangements like vacuum sewerage or on-site treatment arrangement. Bidder is advised to visit the site for any additional information and may carry out necessary assessment after permission from concerned authorities.

23. Testing, Trial runs and Commissioning of the Pumping facility

Testing, performance trial Runs and Commissioning of the Storm Water Pumping facility shall be carried out when:

All civil works as per contract scope, as per approved drawings and as instructed by the Engineer are completed, tested as per technical specifications, and certified approved by the Engineer or his authorised representative

All mechanical, electrical, instrumentation and automation works including PLC-SCADA system as per contract scope, as per approved drawings and as instructed by Engineer are inspected, tested at works, supplied, installed at site and checked for operation and tested for performance and are certified as completed, approved and accepted by the Engineer or his authorised representative

The trial run and testing of individual pumps and the pumping facility shall be carried out using sea water, available storm water or nalla water as directed by the Engineer. During the course of the tests, each pump shall be individually operated over a wide range of operating levels for a minimum period of fifteen minutes without interruption or system failure on each D.G. set and the readings shall be recorded in SCADA. All seven (7) installed pumps shall be demonstrated for continuous operation with D.G. sets, in sets of 4

pumps simultaneously operating in synchronization for at least 5 minutes period without interruption or system failure. In addition, various combinations of numbers of pumps with D.G. sets operating in synchronization shall be run. Each combination should run for a minimum period of 5 minutes without interruption or system failure. All the test results and events shall be recorded in SCADA system for verification with the approved data sheets and characteristics curve(s).

The timing of the tests shall be agreed with the Engineer and will depend upon tidal conditions to ensure that adequate water is available. It may be necessary to carry out the testing over a number of separate periods.

Contractor shall provide a manual method of measurement of the depths in addition to the depth gauges to be supplied as part of the Contract.

All the consumables, spares, power and fuel, skilled staff and engineers, communication gadgets etc. required for testing shall be arranged and paid for by the contractor.

Successful completion of testing of the Storm Water Pumping Facility as described above to the entire satisfaction of the Engineer or his authorised representative and completion of execution of works in entirety shall be construed as successful commissioning of the Storm Water Pumping Station facility and successful completion of 'Part A' of the Contract described elsewhere. The date of certification of successful completion of 'Part A' of the Contract shall be reckoned for levying penalty.

On certification of successful completion of Part A of the Contract (completely or substantially), 'Part B' of the contract i.e. comprehensive operation and maintenance for seven years shall commence.

24. As-built drawings

After completion of entire Civil works, completion of supply, installation and commissioning of all Mechanical, Electrical, Instrumentation and Automation works as specified elsewhere in this tender document, prior to commencement of Operation and Maintenance period, the contractor shall prepare and submit to MCGM, six complete sets of As-built Drawings - two set printed on RTF and six sets on A1 size drawing paper and all six sets shall be laminated; and one set of the drawings in soft form on the compact disc (CD). As-built Drawings are the Detailed Engineering Drawings showing the actual details according to which the Construction/Fabrication/Erection has been carried out. The contractor shall have to obtain approval of the As-built Drawings from MCGM.

25. Operation & Maintenance Manual

Prior to commencement of Operation and Maintenance of the Pumping Station, the Contractor will prepare and submit comprehensive O&M manual for the Storm Water Pumping Station at Mogra that should aid understanding the situation where time may be critical. The O&M manual should present information in the most accessible manner possible (include less narrative and more drawings, schematic, tables, schedules, and checklists). All the manufacturer's literature should be bound separately. The O & M manual shall be spirally bound. An O&M manual shall have following contents:

- Table of Contents
- Introduction and use of manual

- General description,
- Technical data sheet for each equipment and equipment catalogues
- Diagrams
- Operational logic and ladder diagram for Storm Water Pumping Station including Operating instructions and details of sequencing of electromechanical equipment and control information of all electromechanical systems
- Details of Utilities
- Operating and maintenance procedure for each and every equipment including safety procedures
- Approved formats for Operation and Maintenance data logging
- Normal and preventive maintenance schedule
- Emergencies
- List of spares for each equipment and spare parts inventory
- Manufacturers O&M literature
- Operator and management responsibility
- O&M budget requirements
- Additional technical information
- As built drawings
- General arrangement drawing of each equipment

26. Activity Work Schedule with CPM/ PERT

The successful contractor shall submit, within one week of award of contract, a Work Schedule in MS Project format in form of CPM/ PERT in hard and soft copy to MCGM for approval, giving Time Schedule, Critical Path and resource scheduling for each project activity including Civil, Mechanical, Electrical-Instrumentation-Automation works. All the project activities shall be carried out strictly in accordance with approved work schedule. Whenever there is a deviation from the approved work programme, a revised work programme shall be submitted by the Contractor to complete the remaining activities. During the project duration the updated work programme shall be submitted to the Engineer every month.

The Contractor will need to take into consideration limited availability of space, on site and off site activities at the site while preparing the work programme and preparing the activity and resource scheduling.

27. Technical Submission to be made by Tenderer

Tenderer should furnish duly signed and filled forms, functional guarantees, technical data sheets and other such details required to be submitted by him as per Volume 1, Volume 2 and Addenda and as detailed in Section 6, Volume 1 Under Packet B of this tender documents along with his Technical bid.

Adequate technical details of proposal including Layout Plan, design details, design calculations, justification for selection of size / rating / capacities for equipment proposed by him as suitable for design requirements of the Storm Water Pumping Station, details of bar screens, Electrical single line diagram for pumping station, Electrical Load List, Product literature and catalogues, planning details, work methodology etc. in duplicate to enable the

Engineer to review and evaluate the proposal submitted by the tenderer. Tenderers may please note that incomplete submission of his intended proposal may lead to rejection of his tender.

Section 2B

Technical Specifications for Civil Works

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Section 2B – Civil Specifications

PREAMBLE

- 1.0 The "Volume 2 B: Civil Specifications" are to be read for the purpose of pricing in conjunction with "Volume-1: General Conditions of Contract" of the Tender Documents containing Instructions to Tenderer and General Conditions of Contract; "Volume 2 B: Scope of Work" under this tender; "Volume 2 C: Mechanical Specifications", "Volume 2 D: Electrical Specifications" and "Volume-3: Financial Proposal" of this tender.
- 2.0 Abbreviations used in this Volume 2 B : Civil Specifications document have the meanings shown below:

mm	Millimetre	CI	Cast Iron
cm	Centimetre	GI	Galvanized Iron
M	Metre	GSW	Glazed Stone Ware
km	Kilometre	BBCC	Burnt Brick Cement Concrete
Sq.m	Square Metre	RCC	Reinforced Cement Concrete
cum.	Cubic Metre	PCC	Plain Cement Concrete
M.T.	Metric Ton	wt	Weight
SWG	Standard Wire Gauge	kg	Kilogram
R.M.	Running Metre	I.D.	Internal Diameter
nos.	Numbers	C.M.	Cement Mortar
MS	Mild Steel	IS	Indian Standards
M.D	Metre Depth of Manhole	SS	Stainless Steel

1 GENERAL

1.1 Specification Drawings

The site plan, schematic flow diagram and layout plan drawings of the proposed work(s)/plant(s) are incorporated in tender documents. These drawings are made for Tenderer's guidance only.

The Contractor will have to submit General Arrangement drawings, structural drawings as well as detailed RCC design to the Engineer and obtain prior approval to start the construction, erection and commissioning of civil, electrical and mechanical components of the Pumping Station.

Work shall be carried out by Contractor exactly in accordance with the Drawings marked as RELEASED FOR CONSTRUCTION and approved by Engineer-in-Charge and as per the instructions of the Engineer-in-Charge in writing.

1.2 Geo-Technical Studies

Geotechnical investigation report near the proposed Storm Water Pumping Station site is available at the MCGM office for reference of bidders. However, MCGM accepts no responsibility, whatsoever for inferences drawn from this data.

The bidders are free to visit and inspect the sites till the submission date for the purpose of quoting and estimation. The successful bidder shall carry out geo-technical studies on their own cost at the site with prior permission of Engineer. The tenderer shall prepare soil investigation report from MCGM approved soil consultant to the satisfaction of Engineer in charge and furnish the report to the MCGM/PMC Consultant. Only after obtaining approval from MCGM/Consultant, structural design & drawings shall be prepared and submitted. MCGM accepts no responsibility, whatsoever for inferences drawn from this data. It shall be Contractor's responsibility as to the extent to which information is furnished, represents the conditions encountered at site.

1.3 Materials

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

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

All materials shall be new and of the kinds and qualities described in the Contract and shall be approved by the Engineer in- charge.

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.

1.3.1 Samples and Tests of Materials

1. The Contractor should submit test certificates of the materials at the time of material unloading on the site
2. The Contractor shall submit samples of such materials as may be required by the Engineer-in-Charge and shall carry out the specified tests directed by the Engineer-in-Charge at the site, at the supplier's premises and at a laboratory approved by the Engineer-in-Charge.
3. The Contractor should give Engineer-in-Charge seven days notice in writing about the date on which any of the materials will be ready for testing or inspection at the supplier's premises or at a laboratory as approved by the Engineer-in-Charge. The Engineer shall attend the test at the appointed place within 7 days of the said date on which the materials are expected to be ready for testing or inspection according to Contractor, failing to which the test may proceed in his absence unless instructed by Engineer-in-Charge to carry out such a test on a mutually agreed upon date in his presence. The Contractor shall in any case submit to the Engineer-in-Charge within seven days of every test such number of certified copies (not exceeding six) of the test readings as the Engineer-in-Charge in charge may require.
4. Approval by the Engineer-in-Charge as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer-in-Charge's powers under the contract particularly as to the provisions under the conditions of contract.
5. The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.
6. In any case the Contractor shall not use any material without prior testing and clearance by the Engineer-in-Charge. In case such material is used, this will be liable for rejection either partly or fully.
7. If required rejected material shall be marked and stockpiled separately; and such rejected material shall be taken out within a week from construction site.

All costs related to testing of material at supplier's premises as well as on site including all third party inspections/ testing shall be borne by the Contractor. No material shall be used during execution of work without prior testing and obtaining clearance from the Engineer.

1.4 Standards

1. The special attention of the Contractor is drawn to the relevant sections and clauses of the National Building Code of India & Maharashtra PWD specifications and latest BIS Codes (Latest editions along with amendments) and should follow them strictly in addition to the specifications & conditions stipulated in this volume.
2. Materials and workmanship shall comply with the latest relevant Indian Standards (with amendments), unless a more recent amendment is specified hereinafter, or with the requirements of any other authoritative standard approved by the Engineer-in-Charge which shall be no less exacting in the opinion of the Engineer-in-Charge than the corresponding standard quoted here in.

3. Where the relevant standard provides for the furnishing of a certificate to the MCGM on request, stating that the materials supplied comply in all respects with the standard, the Contractor shall obtain the certificate and forward it to the Engineer-in-Charge.
4. The specifications, standards and codes listed below are made a part of this specification. All standards, tentative specifications, specifications, codes of practice referred to herein shall be the latest editions at the time of execution of work including all applicable official amendments and revisions.
5. If no standard is indicated, the relevant Indian Standard, if any, shall apply. Indian standards are published by BIS.
6. Use of equivalent standards of other countries or organizations may be permitted. (Ref.cl. 2, Sec. II B, Vol. II)
7. Hand Book shall be followed, wherever not specified in this "Volume 2: Technical Specifications", Maharashtra PWD specifications and IS specifications shall be applicable in case of discrepancy Engineer-in-Charge's decision will be final & binding. Specifications for different Materials as per IS codes

1.5 List of Important Indian Standards

The following list includes various Indian Standards which are IMPORTANT and are referred to in the general specifications and used in construction works. These standards are to be strictly adhered to unless otherwise is applicable in the relevant context. These standards are to be followed both in respect of materials and construction of civil engineering works included in the tenders.

Though the list of Indian Standards includes the year of Publication of the standard, it may not in all cases be the latest. It is obligatory that only the latest edition of the standard is referred to and followed, along with all amendments and revisions issued with respect to the standard under consideration. This list is not exhaustive but contains only the standards that are very frequently used on the construction works. If a standard exists for a particular item of material or equipment or code of practice the same shall be followed whether the same is included in this list, specifications, other parts of the tender documents or not. Some Indian Standards are referred to in the specifications/ drawings/ other parts of the tender documents and they are supplementing this list if they do not find a place in the list.

Table 1: List of IS with latest revision

Sr.	IS Code No. /year	Title
1	153	Ready mixed paint, spraying, stoving, lead free, for general purposes
2	171	Cotton and cotton regenerated cellulosic fibre blended grey yarn
3	2064	Specification for Structural Steel (Fusion Welding Quality)
4	269	Ordinary and low heat Portland cement
5	383	Coarse and fine aggregates from natural sources for concrete
6	432(part1)	Mild steel and medium tensile steel bars
7	455	Portland slag cement

Sr.	IS Code No. /year	Title
8	456	Code of practice for plain and reinforced cement concrete
9	458	Concrete pipes
10	516	Methods of test for strength of concrete
11	651	Salt-glazed stoneware pipes and fittings
12	783	Code of practice for laying of concrete pipes
13	784	Pre-stressed concrete pipes
14	800	Code of practice for general construction in steel
15	816	Code of practice for use of metal arc welding for general construction in mild steel
16	1038	Steel-doors, windows and ventilators
17	10776	Common burnt clay building bricks
18	1199	Methods of sampling and analysis of concrete
19	1200 (part1-26)	Method of measurement of building and civil engineering works
20	1363 (part 1-3)	Hexagon head bolts, screws and nuts of product grade C
21	1367	Technical supply conditions for threaded steel fasteners
22	1477 (part 1-2)	Code of practice for painting of ferrous metals in buildings
23	1542	Sand of plaster
24	1726 (part 1,2 & 4)	Cast iron manhole covers and frames
25	1786	High strength deformed steel bars and wires for concrete reinforcement
26	2074	Ready mixed paint, air drying red oxide zinc chrome priming
27	2116	Sand for masonry mortars
28	2212	Code of practice for brickwork
29	2250	Code of practice for preparation and use of masonry mortars
30	2339	Aluminum paint for general purpose in dual container
31	2386 (part I-VIII)	Methods of tests for aggregate for concrete
32	2502	Code of practice for bending and fixing of bars for reinforced concrete
33	2720 (part IV,VIII)	Methods of test for soil
34	3006	Chemically resistant glazed stoneware pipes and fittings
35	3370 (part I-IV)	Code of practice for concrete structures for the storage of liquids
36	3696	Safety code for scaffolds and ladders
37	376 (part 1-2)	Safety code for excavation work
38	4082	Recommendations on stacking and storage of construction materials at site
39	4111 (part 1-4)	Code of practice for ancillary structures in sewerage systems

Sr.	IS Code No. /year	Title
40	4127	Code of practice for laying of glazed stone ware pipes
41	6248	Metal rolling shutters and rolling grills
42	6243	Code for rolling shutter.
43	1477	Code for hot dipped galvanizing
44	6909	Super sulphated cement
45	7293	Safety code for working with construction machinery
46	7969	Safety code for handling and storage of building materials
47	Code	National Building Code of India
48	4014	Code of practice for steel tubular scaffolding.
49	5121	Code of practice for deep foundation
50	2911 Part III & IV	Code of practice for design and construction of pile foundation
51	3764	Safety code for excavation work
52	4082	Recommendations on stocking & storage material at site.
53	7293	Safety code of working with construction machinery.
54	3114	Code of practice for laying CI pipes
55	5822	Code of practice for laying of welded steel for pipes
56	7364	Plastic pipe work for potable water supply (part I-III)

Indian Standards Institution
Manak Bhavan
9, Bahadur Shah Zafar Marg
New Delhi - 110 002.

2 SPECIFIC CIVIL REQUIREMENTS

2.1 Design Submissions

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

The design considerations described herewith 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 underground liquid retaining structures.

2.2 Design Standards

All designs shall be based on the latest International or Indian Standard (IS) 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 the Employer's Representative. In case of any variation or contradiction in provisions of the IS Standards/ Reference Codes and the specifications given in tender document, the provisions given in the Specification shall govern.

All reinforced concrete structural design shall generally conform to the following codes of practice:

- (i) I.S. 456 : Code of Practice for plain and reinforced concrete
- (ii) I.S. 875 : Code of Practice for design loads for buildings and structures
- (iii) I.S. 1893 : Criteria for earthquake resistant design of structures
- (iv) I.S. 2974 : Code of Practice for design and construction of machine foundations (Part 1 to 4)
- (v) IS-3370 : Code of Practice for Concrete Structure for the Storage of Liquids
 - Part- I – General Requirement
 - Part-II – Reinforced Concrete Structure.
 - Part-III- Pre-stressed Concrete Structure.
 - Part- IV – Design Tables.

2.3 Design Loading

All building 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 and uplift pressure.

2.3.1 Dead Load

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

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

Sr.	Parameter	Load
(i)	Weight of water	10.0 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	20.0 KN/m ³
(iii)	Weight of plain concrete	24.0 kN/m ³
(iv)	Weight of reinforced concrete	25.0 kN/m ³
(v)	Weight of brickwork (exclusive of plaster)	22.0 kN/m ³ per mm thickness of brickwork
(vi)	Weight of plaster to masonry surface	18.0 kN/m ³ per mm thickness
(vii)	Weight of granolithic terrazzo finish or rendering screed, etc.	24.0 kN/m ³ per mm thickness
(viii)	Weight of sand (filter media)	25 kN/m ³

2.3.2 Live Load

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

Sr.	Location	Live Loads
1.	Floor supporting Pumping Machinery or any other Mechanical/Electrical/Instrumentation/ Automation equipment	Minimum 1000 kg/sq.m Or 1.5 Times actual weight of equipment whichever higher
2.	Storage	750 kg/sq.m
3.	Platform, Staircase, Corridor, Walkways, Office etc.	500 kg/sq.m
4.	Toilet	200 kg/sq.m
5.	Roof slab without access	150 Kg/sq.m
6.	Roof slab with access	300 Kg/sq.m.

In the absence of any suitable provisions for live loads in IS Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of

the Employer's Representative prior to starting the design work. Apart from the specified live loads or any other loads 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.

2.3.3 Wind Load

Wind loads shall be as per IS: 875

2.3.4 Earthquake Load

This shall be computed as per IS: 1893

2.3.5 Dynamic Load

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

2.3.6 Other Loads

In addition to earth pressure and water pressure etc., the surcharge of 1 Ton/sq.m shall be taken into account in the design for channels, tanks, pit, RCC units below ground etc.

The approach road and the road on the platform shall be designed for AA class of IRC loading.

2.4 Joints

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure as per relevant IS code provisions. Expansion joints of suitable gap at intervals not more than 30 m shall be provided in walls, floors and roof slabs of water retaining structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided on convenience of construction. To avoid segregation of concrete in walls, horizontal construction joints are normally to be provided at every 2 m height, PVC water-stops of suitable type and minimum 230 mm width, 6 m thick shall be used for walls and base slabs.

2.5 Design Conditions for Underground or Partly Underground Liquid Retaining Structures

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

1. Liquid depth up to full height of wall (irrespective of the actual height of liquid in tank and free board) and no relief due to soil pressure from outside to be considered.
2. Structure empty (i.e. empty of liquid, any material, etc.) full earth pressure including saturated condition and surcharge pressure wherever applicable to be considered.
3. Partition wall between two compartments to be designed as one compartment empty and other full
4. The structures shall be designed considering ground water saturation upto Finished Ground Level.

5. The dead weight of the empty structures should provide a safety factor of not less than 1.2 against uplift pressures during construction and in service.
6. All members in contact with sea / flood water shall be checked and designed for the effect of tidal force (Maximum Tide of 5.5m shall be considered) and flood force including impact of floating matter.
7. Wall shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads;

Underground or partially underground structures shall be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab.

The walls and base slabs shall be designed for saturated earth/ water pressure corresponding to high flood level.

2.6 Bored Cast in Situ RCC Piles

Codes, Standards & Specification

- a. IS: 2911 (All Parts)
- b. Specification for materials for Reinforcement concrete piles.
- c. Specification for construction and installation for bored cast in situ piles.
- d. Specification for testing of concrete piles

2.6.1 General

Providing RCC bored cast in situ piles and R.C.C. pile caps as per approved design carried out by the bidder, vetted by the Consultant and duly approved by MCGM and submitting to MCGM for review before commencement of piling work. The scope in general consists of designing the RCC pile foundation on the basis of soil investigation report / recommendation, which shall be carried out by the successful bidder. The testing of piles shall also be carried out by the contractor in line with IS 2911– (Part IV) and relevant specifications of this tender document.

2.6.2 Minimum Requirement of Piling Equipment:

Sufficient number of hydraulic self-propelled rotary piling rigs with sufficient torque capacity complete with Casing Adaptor and Casing Oscillator to complete the entire job as per the time schedule shall be provided. The Contractor shall mobilize sufficient spares; cutting tools (e.g. flat teeth bits, round shank bits, holders etc) to avoid any stoppage of work.

2.6.3 Surveying and Staking:

It is the express responsibility of the contractor to bring to site all surveying instruments necessary for the marking out, fixation of levels, etc. and conduct these survey operations himself with utmost accuracy. The contractor shall put up stable benchmarks etc. as necessary for the work. The contractor shall be entirely responsible for accurate setting out of the work and he shall at his own expense make good any defects arising from errors in line and levels.

The scope also includes carrying out routine load tests as specified on randomly selected job piles selected by Engineer-in-Charge and as per IS code provisions.

All work shall be carried out in accordance with the specifications enclosed herewith:

2.6.4 Termination of Piles:

Piles shall be terminated with a minimum embedment in compatible strata as specified in investigation report and approved by consultants/ Engineer as per design requirements. The level of encountering the particular strata and termination depth in all cases shall be certified by Engineer-in-Charge and shall be binding on the tenderer.

- A) Unit penetration interval say 1000 mm shall be maintained constant.
- B) Time required to achieve standard penetration of 1000 mm shall be recorded.
- C) RPM of Kelly bar shall be measured physically (for 1 full minute).
- D) Pressure gauge reading of applied hydraulic pressure shall be limited to 20 MPa.
- E) Kelly bar RPM shall be about 10/11 at the time of terminating of pile.
- F) Record of every 1000 mm penetration shall be maintained jointly by contractor & supervising authority.
- G) Rock sample collected in every penetration shall be stored and labelled.
- H) After correlating with nearby borehole on meeting rock, minimum specified socket shall be provided in rock. Out of this about one diameter length of socket is required in good rock. To ensure, one diameter socket will be provided in rock requiring pressure of 20 MPa.

2.6.5 Safe Load Carrying Capacity for Vertical Compression / Lateral / Uplift:

The tenderer shall guarantee minimum safe load of 2.5 times the design capacity for the piles provided. The safe load may be increased by 25% in the case of wind and seismic.

2.6.6 Materials:

Materials shall conform to specifications for materials for Reinforcement concrete which is enclosed elsewhere in this tender document and forming a part of the tender.

2.6.6.1 Concrete:

The concrete shall have a minimum strength of 40 N/mm² at 28 days. The cement for concrete shall be Ordinary Portland Cement with GGBS or Portland slag cement having minimum cement content not to be less than 450 kg/cum and a max water cement ratio of 0.40. The cement content shall be governed by Design mix or soil characteristics, whichever is higher. The allowable slump shall be as per relevant latest revision of IS codes (IS 2911 Part 1/Sec 2). The Engineer-in-Charge may allow marginal adjustment in water/cement ratio to obtain concrete of good workability. The other concrete specifications shall be as per relevant clauses of Design, Construction & Installation of Bored cast-in-situ piles forming part of this tender. For substructures M40 Grade concrete (mix design) and for super structures M-30 Grade concrete (mix design) shall be used.

2.6.6.2 Reinforcement:

Reinforcement shall conform to IS: 1786 (latest version) grade Fe-500 for mechanical properties and shall be Corrosion resistant steel and it shall be either "TISCO CRS" from TISCO or HSCR-M from Vizag Steel or HCR-M from SAIL only. The reinforcement in the pile shall consist of the following:

- Longitudinal / Ties / Spacer bar Reinforcement

- Reinforcement provided shall be as per approved design with respect to diameter, numbers and should run through the entire length of the pile. Clear cover to reinforcement shall be as per approved design (min 75mm).

2.6.7 Installation:

Installation of piles shall be carried out in accordance with the pile lay out drawings as prepared / vetted / approved which are prepared by the contractor at the time of execution of work.

Cut-off level of the piles shall correspond to those given in the working drawings.

To ensure dense and sound concrete up to cut-off level, concreting shall extend minimum 600mm above cut-off level.

In case the reinforcement cage is made up of more than one segment, the same shall be assembled by welding only, before lowering, as per IS: 456-2000 by providing necessary laps.

The vertical reinforcement shall project 50 times its diameter above the cut-off level.

Pile shall be constructed by using temporary guide casing or permanent liners up to minimum 1.5m to 3.0m inside the stiff to very stiff clay exists below very soft / marine clay as per site conditions or design requirements. Concrete shall be placed by tremie. All precautions for obtaining clean and sound pile shaft shall be strictly observed.

Piles showing unsatisfactory results shall be treated as defective piles. Defective piles shall be removed or left in place and replaced by additional piles as directed by Engineer-in-Charge at no additional cost to the owner. Reaction piles, if required for the purpose of conducting load tests on piles shall not be paid extra.

2.6.8 Routine Load Test:

Routine load tests shall be carried out up to one and half times the design load. The piles for the test shall be randomly selected by the Engineer-in-Charge.

2.6.8.1 Pile Load Test Details:

- i) For pile load tests, the test set up shall be as per IS 2911 Part IV and specifications for testing of concrete piles.
- ii) All testing shall be done by direct method of loading in successive increments as per the relevant clauses of IS: 2911 Part IV & Standard Specifications for testing concrete piles forming a part of this tender.
- iii) Each stage of loading shall be maintained till the rate of movement is less than 0.2 mm per hour. Test shall be carried out at the cut-off level.

2.6.8.2 Number of Tests Required:

The number of tests required shall be as per relevant clause of IS 2911 Part IV.5.6.6

Kentledge load shall be at least 25% higher than the maximum test loads.

Safe vertical load on single pile shall be the least of the following:

- i) Two thirds of the final load at which the total settlement attains a value of 12 mm.
- ii) 50% of the final load at which the total settlement equals to 10% of the piles dia.

Safe lateral load on single pile shall be least on the following:

- iii) 50% of the final load at which the total lateral displacement equals to 12 mm.
- iv) Final load corresponding to the total displacement of 5 mm.

A full record of pile load test results shall be submitted in triplicate to the Engineer-in-Charge immediately on completion of each test. The record shall also include the plots of load-settlement (for various stages of loads) characteristics of pile and also the interpretation of the pile load test curve as per criteria for safe loads mentioned in the specifications for testing concrete piles forming a part of this tender. Any special observations shall be duly explained by the contractor.

Replacement of Rejected Piles / boring / casing that are defective or exceed the tolerances specified in IS code shall be left in place or pulled out as directed by Engineer-In-Charge without adversely affecting the performance of the adjacent piles. In case the piles / casing cannot be removed they shall be cut out as directed by Engineer-in-Charge. Voids resulting from rejected borings or extraction of the piles or casings shall be filled with gravel or sand unless other piles are installed in such voids at the cost of contractor.

Pumping and bailing out of water, shoring, strutting, etc., if found necessary for successful and speedy operation of work shall be carried out by the contractor

All the excavated materials including debris, loose earth, muck etc shall be carted away and disposed off by the contractor out of the premises to any suitable place as per local statutory authorities.

Control of Piling Installation shall be as per the relevant IS Code (IS 2911 (part 1 section 2).

Piles that are defective shall be left in places as judged by Engineer-in-Charge and additional piles shall be driven to replace them at no extra cost.

Adequate length of bars to be left over the cut-off level of the pile to develop anchorage in the pile caps and also dowels to be kept of adequate lengths.

Sample of the hard strata shall be taken, appropriately marked and preserved by the contractor and finally handed over to MCGM. The level on the container should specify the date of piling, pile marked and depth of strata from which the sample has been obtained. Rig register and weekly report as per the format, approved by MCGM shall be submitted to Engineer-in-Charge.

All piles shall be concreted to a level 600 mm above the specified pile cut off elevation which shall be 75 mm above the bottom of the Pile cap. For piles cast by tremie method,

in bentonite established bore holes, this level of concreting above pile cut off level shall not be less than 600mm. Before casting the pile cap, this excess concrete shall be cut off up to pile cut off elevation. In case sound concrete is not met with at such elevation the piles shall be cut to such elevation where sound concrete is met. Piles shall be cut off at level and true to elevation shown or specified on the Drawings. Care shall be taken not to damage the reinforcement or the concrete below cut off elevation during such stripping operations. Where stripping to be done to a level lower than the specified cut off elevation to obtain dense and sound concrete, the Contractor shall built up the pile up to cut off elevation at his own cost. Upon completion of the piling work, all casing equipment, construction tools, protective covering and debris resulting from the piling operations shall be removed from the works site with the permission of the MCGM. A minimum length of 1.5-3 metres of temporary casing shall be provided for each bored piles unless otherwise specifically desired. Additional length of temporary casing shall be used depending on the condition of the strata, ground water level etc.

2.6.9 Recording of Data

Daily site records shall be maintained by the Contractor for the installation of piles against each Rig and shall contain the number and dimension of the pile, depth bored (including depth in soft / hard rock), time taken for boring, concreting and empty boring (cut-off level), chiselling and where the pile is wet or dry. Sample bore log in the initial stage or when major variation occurs should be shown. When drilling mud is used, amount of bentonite needed for stabilization of bore, specific gravity of the fresh supply and contaminated mud in the bore hole before concreting shall be checked and recorded regularly. Concrete volume actually cast per pile against required volume and actual cement consumption shall be recorded. Detail of any obstruction encountered, its nature, depth and obstruction shall be recorded. Any deviation from the designated location, alignment or load capacity of any pile shall be noted. Typical data sheet in triplicate for facility of recording piling data to be prepared by the Contractor before starting of actual piling operation at site and information to be recorded against each pile in the data sheet shall be signed by the contractor and countersigned by MCGM. One copy of the data sheet shall be retained by the Contractor and the other three copies to be submitted to MCGM for records & future reference.

At least six photographs are to be taken by the party depicting progress of the job in every week and a set of same to be separately submitted for review and record to MCGM.

2.6.10 Welding:

Field welding of reinforcing bars will not be permitted without the written consent of the Engineer-in-Charge. Where welding is permitted it must be at staggered locations. Tests shall be made to prove that the joints are of the full strength of bars connected. Welding of reinforcement shall be done in accordance with the recommendation of IS: 2751.4.3. The contractor must obtain the approval of the Engineer-in-Charge for the reinforcement placed, before any concrete is placed in the forms. The reinforcement of this time shall be free from loose rust or scale or other coating that will destroy or reduce bond.

Concrete spacer blocks of the same strength as parent concrete shall be used to ensure correct cover to the reinforcement. This clear cover shall be as shown on the drawings or as per instructions of the Engineer-in-Charge. All the reinforcing bars shall be so tied as to form a rigid cage to prevent displacement before or during concreting.

2.6.11 Structural Design:

The piles shall have necessary structural strength to transmit the load imposed on it, to the strata below. Relevant part of IS: 2911 (Part I/ Sec.2) and specific requirements shall be considered to apply for assessing the structural capacity of piles.

2.6.11.1 Reinforcement:

The minimum longitudinal reinforcement shall be 0.4% of the cross sectional area of the pile.

Clear cover to the main reinforcement shall be 75 mm.

The vertical reinforcement shall project 50 times its diameter above the cut-off level.

The minimum clear distance between the two adjacent main reinforcement bars should normally be 100 mm for the full depth of cage. The bars shall be so placed as not to impede the placing of concrete.

The lateral ties in the reinforcing cage shall be preferably spaced not closer than 150 mm centre to centre. The minimum diameter of the lateral ties shall be 8 mm.

Equipment and Accessories

The equipment and accessories for installation of bored case-in-situ piles shall be selected giving due consideration to the subsoil conditions and the method of installation, etc. These shall be of standard type and shall have the approval of the Engineer-in-Charge. The capacity of the rig shall be adequate so as to reach the desired depth. Provision shall be kept for chiselling within the borehole in case of any underground obstruction / hard strata. However, chiselling shall be carried out only with the approval of Engineer-in-Charge. In case pile is required to be socketted in medium or good quality rock strata, the equipment mobilized shall have adequate capability to do so up to the required socket length. For the purpose of classification of rock for the determination of length of socketting, pilot drill holes shall be carried out in the areas to be piled. Rock drilling shall be carried out using double tube core barrel. Drilling and storing of rock cores shall conform to relevant IS codes. Rock quality shall be classified as under depending upon the RQD. RQD (%) ROCK QUALITY < 25 Poor, 25 to 75 Medium,> 75 Good

2.6.12 Piling Installation:

2.6.12.1 Control of Alignment:

The piles shall be installed as accurately as possible as per the designs and drawings. The permissible positional deviations shall be governed by IS: 2911 (Part I /Sec.2). In case of piles deviating beyond such permissible limits, the piles shall be replaced or supplemented by additional piles, as directed by Engineer-in-Charge.

2.6.12.2 Boring:

The boring shall be done by suitable method such as (a) Hydraulic Rotary Drilling method (b) Direct mud circulation (c) Reverse mud circulation(d) Bailer bentonite. The actual method of construction to be followed shall be as per specific requirements. In very soft soil a permanent liner shall be installed to ensure stability of borehole. A liner shall be used to protect the green concrete where a high hydrostatic pressure exists in the subsoil or where an underground flow of water exists and which is likely to damage the concrete on withdrawal of casing. Use of temporary liner only in lieu of bentonite to stabilize sides of boreholes shall not be permitted. Properties of bentonite used and quality control shall be as per IS: 2911 (Part I /Sec.2).

2.6.12.3 Concreting of Piles:

Concreting shall not be commenced until the Engineer-in-Charge satisfies himself that at final borehole depth the soil/ rock is not weaker than that taken as the basis for pile design. If necessary, SPT or similar test shall be conducted to ensure the above.

Borehole bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before lowering the reinforcement cage. The full length of reinforcement cage shall be in position before start of concreting. Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS: 2911 (Part I / Sec.2). Care shall be exercised to preserve correct cover and alignment of reinforcement and avoid any damage to it throughout the complete operation of placing the concrete.

2.6.12.4 Recording of Data:

A competent supervisor shall be present to record the necessary information during the installation of piles. The data to be recorded shall include:

- a) The dimensions of the piles, including the reinforcement detail and the mark of the pile.
- b) The boring method employed
- c) The type of soil in which pile is terminated,
- d) The depth bored.
- e) The depth of water table.
- f) The time taken for concreting.
- g) The cut-off level/working level, and
- h) The consumption of cement concrete.
- i) Any other important observations.

Typical data sheets of recording piling data shall be as given

Any deviation from the designed location, alignment or load carrying capacity of any pile shall be noted and promptly reported to the Engineer-in-Charge.

2.6.13 Testing of Piles:

2.6.13.1 General:

This Specification covers the requirement and methods of testing of a single pile for evaluating its safe capacity in:

- a) Vertical Loading (Compression)
- b) Lateral Loading
- c) Pull Out
- d) Combined Vertical and Lateral Loading)
- e) Special type of loading such as vibratory loadings
- f) Pile Integrity Test

These specifications shall be applicable for all types of piles in general excepting sheet piles.

2.6.13.2 Definitions:

Reference to Indian Standard Codes shall always mean reference to the latest issue of the relevant standards, including all the amendments up to date.

2.6.13.3 Codes:

All testing shall be performed in accordance with the following codes and the provision of these specifications IS: 2911-(Part IV) – Code of Practice for design and construction of pile foundations – Load Test on Piles.

2.6.13.4 Requirements:

The load test shall be required to provide data regarding the load deformation characteristics of the pile up to failure or otherwise specified and the safe design capacity. Full details of the equipment proposed to be used and the test set up shall be submitted to the Engineer-in-Charge with detailed sketches for approval. Approval of the Engineer-in-Charge shall also be obtained after the test set up is complete, prior to commencement of loading.

All measuring devices shall be tested for satisfactory performance and accuracy at an approved institution and a certificate to that effect obtained and submitted to the Engineer-in-Charge prior to use. The test pile shall be constructed using same equipment and technique as for the job piles. A minimum time period of one week shall

be allowed between the time of installation and testing in case of a precast pile and not less than four weeks from the time of casting in case of a cast-in-situ pile.

2.6.13.5 Records:

A full record giving all details of the test in the approved proforma shall be submitted in triplicate to the Engineer-in-Charge immediately on completion of each test. The record shall also include the plot of load time settlement characteristics of piles.

2.6.13.6 Vertical Loading Tests:

The test pile shall be decided by the Engineer-in-Charge. It may be one of the working piles or a separate test pile. The head of the test pile shall be brought to the proper level and provided with a pile cap with a level and plane surface and with adequate space for proper seating of a jack and dial gauges. Test pile surface shall be prepared for testing purposes on the expiry of one week after casting the pile.

Loading shall be applied by the reaction method consisting of a hydraulic jack centrally against a loaded platform. Supports of the platforms shall be adequately designed. Special anchor piles or any other suitable type of anchorage systems may be used. However, use of the uplift capacity of neighbouring piles for providing the reaction shall normally not be permitted. The loading system shall be adequate to ensure that the test can be carried up to the specified limit. The reaction to be made available for the test shall be at least 25% greater than the maximum jacking force required.

2.6.13.7 Loading on Piles:

The load applied on the pile shall be recorded on a calibrated pressure gauge mounted on the jack.

2.6.13.8 Settlement of Pile:

- a) Settlement of the pile shall be recorded by dial gauges suspended from datum bars. Four dial gauges of 0.01 mm sensitivity shall be positioned on four corners around the pile.
- b) The datum bars shall have rigid supports preferably of concrete pillars or steel sections, embedded well into the ground. The supports shall be located more than five times the pile diameter, subject to a minimum of 1.5 m, clear away from the pile face and also sufficiently away from the supports of the loaded platform to avoid any disturbance on these accounts. Movements near the supports of the datum bar shall be avoided while the test is in progress.

2.6.13.9 Method of Conducting Test:

The test shall be carried out by the direct method of loading in successive increments or by the cyclic loading method as specified and as described by the Engineer-in-Charge.

2.6.13.10 Direct Method of Loading in Successive Increments:

The test shall be carried out as per the procedure outlined.

- a) The load shall be applied to the pile top in increments of about of fifth of the rated capacity of the pile or as specified. Settlement readings shall be taken before and after the application of each new load increment and at 2, 4, 8, 15, 30, 60 minutes and at every two hours until application of the next load increment.
- b) Each stage of loading shall be maintained till the rate of movement of the pile top is not more than 0.2 mm per hour or until two hours have elapsed, whichever is later.
- c) Further loading shall then be continued as in (a) above till one of the following occurs:
 - i) Yield of soil-pile system occur causing progressive settlement of the pile exceeding a value of one tenth of the pile diameter.
 - ii) The loading on the pile top equals 2.5 times the rated capacity or as specified in the case of a separate test pile and 1.5 times the rated capacity of the pile in case of a working pile.
- d) Where yielding of the soil does not occur, the full test load shall be maintained on the pile head for 24 hours or more if necessary and settlement readings shall be taken at 6 hours interval during the period.
- e) Unloading shall be carried out in the same steps as loading. A minimum of half hour shall be allowed to elapse between two successive stages of load decrement. The final rebound shall be recorded 6 hours after the entire test load has been removed.
- f) If so directed by the Engineer-in-Charge, loading and unloading cycles shall be carried out for all load stages within the assumed working load.
- g) Assessment of Safe Load: The safe capacity of the pile shall be the least of the following values
 - i) Load corresponding to settlement specified in specific requirements which is based on the nature and type of structure.
 - ii) 50 percent of the final load at which the total displacement equals 10 percent of the pile diameter in case of uniform diameter piles.

2.6.13.11 Cyclic Loading Test:

The test shall be carried out as per procedure outlined by IS: 2911-(Part-IV)

2.6.13.12 Lateral Loading Test:

Equipment and Test Set –up:

The test pile shall be decided by the Engineer-in-Charge. It may be one of the working piles or a separate test pile. The test pile shall be cut off at the proper level and provided

with a cap with vertical plane sides having an adequate area for proper seating of the jack and dial gauges. Loading shall be applied by a hydraulic jack of adequate capacity, abutting the pile horizontally and reacting against the suitable system. The reaction may be provided by the wall of the excavated pit when the test is being conducted below ground level or by a neighboring pile in which case thrust pieces shall be inserted on either end of the jack to make up the gap. Lateral load applied on the pile shall be measured by a calibrated pressure gauge mounted on the jack, having a least count of 500 kg. Deflection of the pile head shall be measured by dial gauges, fixed to datum bars and having a least count of 0.01 mm. The datum bars shall be provided with rigid supports as described above. The test shall be carried out in accordance with the provisions of IS: 2911-(Part-IV) and as detailed below:

Loading shall be applied in increments of 500 kgs or as specified. Each stage shall be maintained for a period till the rate of movement of the pile head is not more 0.2 mm/hr. or 1 hr. whichever is greater. Loading shall be continued till one of the following occurs:

- a) Deflection of the pile head exceeds 12 mm.
- b) The applied load on the pile is 2.5 times the assumed lateral load capacity of the pile in case of a separate test pile and 1.5 times the rated capacity in the case of a working pile. The safe load shall be the smaller of the following: i) Half of the final load for which the total deflection is 12 mm. ii) Load corresponding to 5 mm total deflection. Note: The deflection is at the cut off level of the pile.

2.6.13.13 Pullout Capacity of Piles:

The test pile shall be decided by the Engineer-in-Charge. The test shall be conducted on separate pile installed specifically for this purpose. The test pile shall be built up to the proper length and the head provided with suitable arrangements for anchoring the load applying system. Load shall be applied using an approved reaction system. Uplift force on the pile maybe applied directly to the test pile or through a level system. The reaction may be provided by neighboring piles or blocks may be constructed for the purpose. A hydraulic jack shall be used for load application. Load applied by jack shall be measured by a calibrated pressure gauge with a least count of 1000 kgs. Movement of the pile shall be measured by dial gauges, fixed to datum bar and having a least count of 0.01 mm. A minimum of two dial gauges, placed diametrically opposite shall be used. Datum bars shall be provided with rigid supports as described above. The test shall be conducted as outlined below:

Loading shall be applied to the pile top in increments of one fifth the rated capacity of pile. Each stage shall be maintained for a period till the rate of movement of the pile head is not more than 0.2 mm/hr or one hour, whichever is greater. Loading shall be continued till one of the following occurs:

- a) Yield of soil pile system occurs causing progressive movement of the pile exceeding 12 mm.
- b) The loading on the pile top equals twice the estimated safe load or as specified.

The safe capacity of the pile shall be the least of the following: a) Two-thirds of load at which the total displacement is 12 mm or the load corresponding to a specified

permissible uplift, and b) Half of the load at which the load displacement curve shows a clear break.

2.6.13.14 Combined Vertical and Lateral Loading:

The equipment and test set up shall be same as described above. In addition, a platform shall be constructed on the pile top, and loaded to 1.0 times the pile capacity in vertical loading. The pile shall be first subjected to the full vertical load. The lateral load shall commence after all settlements due to the vertical load have ceased and while the full vertical load is in position. The loading system, measuring system and recording of the results shall be the same as described above.

2.6.13.15 Pile Integrity Test:

Pile Integrity Testing (PIT) is a Non-Destructive integrity test method for foundation piles. The method evaluates continuity of the pile shaft and provides information on any potential defects due to honeycombs, necking (cross-section reduction), potential bulbs, sudden changes in soil stratum, concrete quality in terms of wave speed etc. It is known as "Low Strain" method since it requires the impact of only a small hand-held hammer and the resultant strains are of extremely low magnitude. The test procedure is standardized as per ASTM D5882 and also forms part of various specifications and code provisions worldwide.

2.6.13.16 Test Equipment:

Equipment: PIT-V Equipment manufactured by Pile Dynamics, Inc., USA compliant with ASTM D5882

Software: PIT-W 2009 Software Standard Version

This is currently best equipment available worldwide with use in most countries across the world. The equipment includes a sensitive accelerometer and a non-instrumented hammer, in addition to the device. The data is displayed on the field for preliminary evaluation and interpretation, and a field printout is possible

2.6.13.17 Site Arrangements:

The pile head with sound concrete shall be available for testing. For this pile head should be chipped off up to cut off level or up to the depth where sound concrete is available. The sound concrete level can be obtained after removal of any debris, muck etc. from the top.

The pile concrete should attain atleast 75% of its required compressive strength before testing is conducted. This can be checked with the help of 7 and 28 days' cube test results.

The pile head at the testing level shall be made reasonably flat by chipping or by chisel. In some cases, it can even be done using a grinder or carborundum stone. Ensure that concrete is sound, hard and good. No high strength mortar or cement paste shall be applied on the pile top to make it smooth and even.

The projecting rebars need to be bent outside for easy access within core region. Safe and reasonable access to the pile is the responsibility of the CONTRACTOR

2.6.13.18 Anchoring

Special attention is drawn to danger of uplift being caused by the ground water table. Ground water table shall be considered at finished ground level for all underground structural slabs. Anchoring may be permitted for designing the structures against uplift forces.

Anchoring against uplift shall be permitted for deep structures on the basis of rock and soil profile obtained after investigations carried out at specific locations

Construction of Anchor Holes

Drilling for anchors shall be completed by pneumatic methods, as per installation pattern, sizes and lengths provided in drawings. Borehole sides shall be adequately protected against side collapse by use of PVC Casing. The anchor hole should be perpendicular to the anchor bearing plate. The deviation of the anchor hole entry angle from its inclination as specified the Contract Documents shall be no greater than ± 3 degrees.

Design of Uplift Anchors

- a) Pre-stressed Rock Anchors: These anchors shall be strictly designed as per IS 10270.
- b) Passive Rock Anchors: Following guild lines shall be followed during design of these type of anchors. Length of the anchor is selected longer of the following lengths. Design Anchor shall be longest length calculated below.
- c) Length required to mobilize shear force at Rock and Grout interface which is equal to anchor force.
- d) Length required to mobilize shear force at Steel and Grout interface which is equal to anchor force.
- e) Length required to provide anchor across sufficient number of natural joints to ensure macro level stability.
- f) Length required to contain rock mass of dead weight equal to 100 percent total uplift /anchor force.
- g) Development Length for equivalent diameter of reinforcement Steel bar/s.

Anchor Installations:

- a) HT Strands of 12.7mm or 15.2 mm dia. Or equivalent TATA SSL OR USHA MARTIN conforming to LRPC class II as per IS 14268 shall be cut to length of anchor including that required for stressing purpose. Working loads on strands shall not exceed 60% of the characteristic strength of the strands. Strand testing certificates to be provided by manufacturer for each lot for test conforming to IS 1521-1972 (Method of tensile Testing).
- b) For The strands in free length, a coat of primer shall be brush applied. Also a flexible PVC sheath of HDPE, 2mm thick shall be provided over each individual

strand within the free length. The top and bottom of the HDPE sheeting shall be taped at top & bottom.

- c) Prepared strands shall be grouped together. Spacers shall be used to separate the strands or bars individually or into small groups at regular intervals of 1.5m in fixed length. The strands shall be tied with the help of binding wires at the center of two spacers. A MS guide shoe shall be welded to the bottom of the strands by brazing for lowering the anchor in the bore.
- d) The strands shall be pre-treated to remove rust/oil, scaling, grease, etc. three coats of epoxy formulation shall be applied on the strands. The 2nd coat shall be applied only after allowing the 1st coat to dry for 2-3 hours. Quartz sand shall be sprinkled to roughen the surface.

Following epoxy formulation shall be used:

Araldite: GY257 (2 Parts) or Sikka (2 parts), Aradur hardener– gy140 (1 Part) or equivalent.

- e) Centralizer shall be utilized to support the tendon in the drill hole and position the tendons so a minimum grout cover of 12mm is achieved. All centralizers shall be designed to permit grout to flow freely around the tendon and up the drill hole. The contractor shall determine the number of centralizers required; however, a minimum of one unit shall be placed within 1m of the bottom of the hole and another at the bond length and free stressing length interface.
- f) A PVC grout tube of 25mm diameter shall be inserted through all the cable spacers to facilitate grouting. Care shall be taken to ensure that the sheathing, corrosion protection and grout tubes are not damaged during installation.

Primary Grouting of Anchors:

- a) The grout shall entirely fill the annular space between the strands and the borehole wall in the bond length.
- b) Mechanically operated drum mixer of minimum 100 L capacity shall be used to prepare the grout. Grouting shall be done in fixed length by providing a packer at top of fixed length or by ensuring with physical measurements that grout does not intrude the free length portion.
- c) Fixed length grouting shall be done by high strength chemical grout by providing a packer at the top of fixed length or by ensuring with physical measurements that grout does not intrude the free length portion. Free length grouting shall be done with minimum 43 grade OPC cement neat cement grout with non-shrink admixture.
- d) Three (3) grout cubes (7.5cm x 7.5cm x 7.5cm) shall be cast for each day of grouting. One cube shall be tested at 7 days while the remaining cubes shall be tested at 28 days.

Stressing & Locking of Anchorage:

Stressing shall not commence until the grout has reached its 28 –Day strength. The anchors shall be proof tested to 1.1 times the design load in 5 increments as per IS 10270. Jack calibration certificate of ISO or NABL accredited laboratory dated within 6 months of use, should be available on site. The initial increment of 10% of design load

shall be applied. Elongation should be measured at each of the 5 load increments with a scale or ruler at Stressing Jack. The load shall be held at the final test load for at least 10 minutes. If the movement between 1 minute and 10 minutes of holding at final load exceeds 1 mm, then the maximum test load shall be held for an additional 15 minutes. The anchor can be deemed acceptable upon proof testing if all the below conditions are Satisfied:

- i. Elongation is less than 1 mm between 1 minute and 10 minutes of holding at final load.
- ii. Total elongation exceeds 80% of theoretical elongation of free length.
- iii. Total elongation is less than the theoretical elongation of free length.

The load shall then be released and the anchor locked off at desired lock off load with Wedges. Wedge holes and wedges shall be free of rust, grout, and dirt. The free length shall then be grouted. As built drawings to be provided by contractor, showing location of anchor positions, in case of any deviation.

2.7 Foundation

1. Foundation design shall be as per the site conditions and geotechnical requirements.
2. The earth fill above virgin ground level till formation level shall be taken as a surcharge load and shall be added in the loads coming on foundations appropriately
3. Geo-technical investigation should be done by the Contractor from MCGM approved soil consultant and the report should be furnished to the Client/Consultant and should be approved by MCGM/Consultant prior to start of structural design & drawings. Number of bore holes drilled in Geotechnical Investigation shall not be less than 13. At least one borehole shall be drilled in the plan area of each component building. Depth of boreholes shall extend up to at least 15m in hard rock below Invert Level / Plinth Level of the structure, whichever is deeper. Permeability of bedrock shall be checked by Packer Permeability Tests till minimum depth of 5m below Invert Level. Each Packer Test Section shall not be made more than 1.5m in length
4. Care shall be taken to avoid the foundations of adjacent buildings or structure foundations, either existing or not within the scope of this Contract Suitable adjustments in depth, location and sizes may have to be made depending on site conditions. No extra claims for such adjustments shall be accepted by the Employer.
5. a) Special attention has been drawn to unfavourable effects of uplift caused by Ground Water Table. Almost all structures are likely to experience uplift due to high ground water table.
b) If uplift forces are large (more than 40(MT) it is desirable that prestressed rock anchors are provided. Prestressed rock anchors shall be designed conforming to latest version of IS: 10270-Guidelines for Design and Construction of Prestressed Rock Anchors.
c) When uplift pressure is less than 40MT, use of prestressed rock anchors becomes uneconomical. In such a case, it is a practice to use passive / unstressed rock anchors. IS: 10270 does not explicitly cover any aspects of the same. It is specified that the design methodology in Appendix A for design of passive / unstressed rock anchors installed under this contract shall be carried out only by the specified method.
6. Top of tanks shall be at least 500 mm above high flood level or FGL, whichever is more.

2.8 Design Requirements

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

1. All blinding and leveling concrete shall be minimum 100 mm thick in concrete grade M20 for Building & 150 mm thick in M25 minimum for Water Retaining Structure.
2. All structural reinforced concrete shall be with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all the Water Retaining Structures & other structural members.
3. All liquid retaining structures shall be designed as per IS: 3370 as Uncracked Section. The minimum grade of concrete shall be M 40.
 Grade of concrete for all structure shall be M40.

Minimum cement content in various grades of concrete

Sr. No.	Material	Quantity
Grade of Concrete		M40
1	Total minimum cement content	450kg/cum
2	Ordinary Portland Cement – 53 Grade Ground Granulated Blast Furnace Slag (GGBS)	Minimum 50% of total cement content Maximum 50% of total cement content
OR		
3	Portland Slag Cement with maximum 50% GGBS.	

5. The amount of reinforcement in each of the two directions at right angles within each surface zone should not be less than the minimum specified as IS: 3370 or IS: 456 whichever is applicable for the type of structure.
6. Use of pressure relief valves to reduce uplift pressure due to ground water table shall not be allowed.
7. All pipes and ducts laid below the structural plinth and road works shall be surrounded with concrete of grade M 20.

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

Sr.	Civil Member	Thickness (mm)
(i)	Walls for liquid retaining structures	250
(ii)	Bottom slabs for liquid retaining structures	250
(iii)	Wall foundation for wall of liquid retaining structures	300
(iv)	Walls of Launders	150
(v)	Base slab of Launders	150

Sr.	Civil Member	Thickness (mm)
(vi)	Roof slabs/Domes for liquid retaining structures	150
(vii)	Floor slabs including roof slabs, walkways canopy slabs	150
(viii)	Walls of cables/pipe trenches, underground pits, etc	150
(ix)	Footing at Edge	200
(x)	Footing at Face of Column	450
(xi)	Column – Width	300
(xii)	Column – Depth	300
(xiii)	Beam – Width	230
(xiv)	Beam – Depth	450
(xv)	Parapets, Chajja	125
(xvi)	Precast trench cover	100

2.9 Minimum Cover to Main Reinforcement

Sr.	Member	Details	Cover (mm)
1.	Slab	Free Face	30
		Face in contact with earth	30
2.	Beam	Top/Bottom	40
		Side	40
3.	Column and pedestal	Face in contact with earth	50
		Super Structure	40
4.	Retaining wall, Basement and Pit wall	Face in contact with earth	50
		Free face	50
5.	Liquid Retaining Structure	Face in contact with liquid	75
		Face in contact with earth	75
		Free face	50
6.	Foundation/raft	Bottom	75
		Top	75
		Sides	75

2.10 Minimum Bar Diameter

	Member	Diameter (mm)
1	Major Foundation	10
2	Block Foundation – Main Bars	10
3	Block Foundation – Tie Bars	8
4	Minor Foundation (Local Foundation etc.)	8
5	Column, Pedestal – Main Bars	12
6	Column, Pedestal – Ties	8

	Member	Diameter (mm)
7	Beam – Main Bars	12
8	Beam – Anchor Bars	12
9	Beam – Stirrups	8
10	Slab – Main Bars	12
11	Slab – Distribution Bars	8
12	Wall – Main Bars	10
13	Wall – Distribution Bars	10
14	Foundation	10
15	Base Slab – Main Bar	10
16	Base Slab – Distribution Bar	10
17	Wall Foundation – Main Bar	10
18	Wall Foundation – Distribution Bar	10
19	Minor elements such as chajja etc.	8

2.11 Bar Spacing

SR	Member	Minimum (mm)	Maximum (mm)
1	Foundations	125	200
2	Slabs	100	300
3	Stirrups for Beams	100	300
4	Ties for Columns, Pedestals	100	250
5	Walls	100	250

* Bar spacing shall be provided in multiple of 25 mm.

2.12 Architectural Details of Civil units

Building	Storey	Minimum Carpet Area (SqM)	Room Type	Main Str. Constr.	Plinth Height (mm)	Ceil. Height (mm) Upto Soffit of Beam	Roof	Brick Work		Flooring			Doors / Windows			PLASTER			PAINTING			Roof Water Proofing
								Ext. (mm)	Int. (mm)		Door	Win.	Roll. Stutter	Ext.	Int.	Ceil.	Int.	Ext.	Ceil.			
Admin Office to be located above the Main Electrical Panel and Operation House	Located on floor above the electrical panel	350	Engineering Room (3nos.) + 1 no Conference room + Hall including pantry + Record room	RCC Framed	NA	4000	RCC	230	230	Approved full body Vitrified tiles, 600mm x 600mm	Anodised Aluminium with FRP/ Glass panels	Anodised Al.	- Sliding	Double coat 20 mm thick plaster in CM 1:3	Single coat neeru POP finish 12 mm thick plaster in CM 1:3	6 mm thick / plaster with POP finish in CM 1:3	Approved Oil Bound Distemper	Approved Water proof roof Cement Paint	Approved Oil Bound Distemper	India water proofing on Brickbat Coba or Equivalent		
			Toilet	RCC Framed	NA	4000	RCC	230	115	Anti skid full body vitrified tile flooring and full body vitrified tile dado as approved by the Engineer-in-Charge up to lintel level	Anodised Aluminium with FRP/ Glass panels	Anodised Al.	- glazed louvers with 1 no.exhaust fan	Double coat 20 mm thick plaster in CM 1:3	Single coat neeru POP finish 12 mm thick plaster in CM 1:3	6 mm thick / plaster with POP finish in CM 1:3	Approved Oil Bound Distemper	Approved Water proof roof Cement Paint	Approved Oil Bound Distemper	India water proofing on Brickbat Coba or Equivalent		
			Staircase	RCC framed			RCC	230		Kota stone treads and risers	Anodised Aluminium with FRP/ Glass panels	-	-	Single coat neeru POP finish 12 mm thick	6 mm thick / plaster with POP	Approved Oil Bound Distemper	Approved Water proof roof Cement Paint	Approved Oil Bound Distemper	India water proofing on Brickbat Coba or Equivalent			

Building	Storey	Minimum Carpet Area (SqM)	Room Type	Main Str. Constr.	Plinth Height (mm)	Ceil. Height (mm) Upto Soffit of Beam	Roof	Brick Work		Flooring		Doors / Windows			PLASTER				PAINTING				Roof Water Proofing
								Ext. (mm)	Int. (mm)			Door	Win.	Roll. Stutter	Ext.	Int.	Ceil.	Int.	Ext.	Ceil.			
Main Electrical and Operations Building	2	350	SCADA & PLC panel room with false ceiling	RCC Framed	4500	RCC	-	-		Polished Kota Stone	Anodised Aluminium with Glass/FRP panels	Anodised Al. Sliding	-	-	Single coat neeru / plaster POP finish 12 mm thick	6 mm	Oil Bound Distemper	-	-	-	India water proofing on Brickbat Coba or Equivalent		
			Battery room							Acid resistance tiles as approved by the Engineer-in-Charge	Anodised Aluminium with Glass/FRP panels	Anodised Al. Sliding	-	-	Single coat neeru / plaster POP finish 12 mm thick	6 mm	Oil Bound Distemper	-	Oil Bound Distemper	-			
			Toilet	RCC Framed	4000	RCC	230	115	Anti skid full body vitrified tile flooring and full body vitrified tile dado as approved by the Engineer-in-Charge up to lintel level	Anodised Aluminium with Bakelite panel	Anodised Al. glazed louvers with 1 no.exhaust fan	-	Double coat 20 mm thick plaster in CM 1:3	Single coat neeru / plaster POP finish 12 mm thick	6 mm	Oil Bound Distemper	Waterproof Cement Paint	Oil Bound Distemper	India water proofing on Brickbat Coba or Equivalent				

Building	Storey	Minimum Carpet Area (SqM)	Room Type	Main Str. Constr.	Plinth Height (mm)	Ceil. Height (mm) Upto Soffit of Beam	Roof	Brick Work		Flooring		Doors / Windows			PLASTER				PAINTING				Roof Water Proofing
								Ext. (mm)	Int. (mm)			Door	Win.	Roll. Stutter	Ext.	Int.	Ceil.	Int.	Ext.	Ceil.			
Storm Water Pumping Station	On the Format ion Level	300 excluding sluice gates and screen area	-	RCC Framed	500	As per requirement for lifting of pumps	RCC	230	230	Polished Kota stone	Anodised Aluminium with FRP / Glass panels	Al. Sliding	Galvanised Iron	20 mm thick plaster in CM 1:3	12 mm thick plaster in CM 1:3	6 mm thick plaster in CM 1:3	Oil Bound Distemper	Waterproof Cement Paint	White Wash	India water proofing on Brickbat Coba or Equivalent			
Buildings above firewater tank / potable water tank / tank for jetting water / security cabin	On the Format ion Level	300	-	RCC Framed	500	3000	RCC	230	230	Polished Kota stone	Anodised Aluminium with FRP / Glass panels	Al. Sliding	Galvanised Iron	20 mm thick plaster in CM 1:3	12 mm thick plaster in CM 1:3	6 mm thick plaster in CM 1:3	Oil Bound Distemper	Waterproof Cement Paint	White Wash	India water proofing on Brickbat Coba or Equivalent			

Notes:

1. All doors, windows, external & internal paints shall be as per MCGM approved vendor list
2. All doors and windows shall be approved as per MCGM fire department rules & regulations
3. All external concrete surfaces of superstructures including water retaining structures above FGL shall be painted with waterproof cement paint of make approved by MCGM.
4. All concrete surfaces in contact with water and all concrete surfaces in contact with subsoil shall have approved PU-based epoxy coal tar 300 micron thick in two coats of 150 micron each.

2.13 Buildings and Structures

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

All building works shall be reinforced concrete framework with concrete floors and roofs.

All internal and external walls shall be in 230 mm thick brick masonry built in cement mortar 1:3. For Toilet Blocks internal partition walls shall be in 115 mm thick brick masonry built in cement mortar 1:3.

Toilet floor slab shall be filled with brickbat coba and provided with waterproofing as per the specifications of an approved specialist waterproofing company.

The finished floor level in Toilet-cum-Bathroom areas shall be 25 mm below general finished floor level elsewhere in the building.

1. The toilet facilities shall be provided in office building separately for men and women which include at least :

- (i) 2 Nos. Water closets each (1 No. for men and 1 No. for women), one no. European and one with white porcelain Orissa pan minimum 580 mm long with flushing cistern of 10 litres capacity.
- (ii) 3 Nos. Urinals (for men) of sizes 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a marble partition of size 680 mm x 300 mm.
- (iii) 2 Nos. wash basins (1 No. for men and 1 No. for women) of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.
- (iv) 2 Nos. mirrors (1 No. for men and 1 No. for women) of size 400 mm x 600 mm wall mounted type fitted over wash basins.
- (v) 2 Nos. plastic liquid soap bottles (1 No. for men and 1 No. for women)
- (vi) 2 Nos. chromium plated brass towel rails (1 No. for men and 1 No. for women) minimum 750 mm long.
- (vii) All stopcocks, valves and pillar cocks shall be heavy duty chromium plated brass.
- (viii) All fittings such as 'P' or 'S' traps, floor traps, pipes, downtake pipes etc.
- (ix) The sewage from toilet blocks shall be connected to nearby sewer network / septic tank.

All internal staircases shall be provided with polished kota stone treads and risers.

All floor cutouts and cable ducts, etc. shall be covered with precast concrete covers in outdoors areas and mild steel checkered plates of adequate thickness in indoor areas. Floor cutouts above pump bay shall be covered with galvanized iron gratings of adequate thickness. All uncovered openings shall be protected with Stainless Steel 304 hand railing.

All staircases shall be provided with Stainless Steel 304 pipe and hand railing for protection.

For roofing drainage, uPVC rainwater down takes with uPVC bell mouth and stainless steel grating at top shall be provided. For roof areas up to 40 sq.m. minimum two nos. 100 mm diameter down take pipes shall be provided. For every additional area of 40 sq.m. or part thereof, at least one no. 100 mm diameter down take pipe shall be provided.

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 rainwater.

All doors, windows, rolling shutters shall have lintels above. Chajja protection to lintels on external walls shall be such as to prevent the rainwater splashing into the building. The minimum width of chajja for doors, windows, and rolling shutter shall be 750 mm, 600 mm, and 900 mm respectively.

All windows and ventilators shall have 25 mm thick Green marble frame in cement mortar (1:3)

The design of buildings shall reflect the climatic conditions existing on site. Process buildings shall be as far as is possible permit the entry of natural light.

The sidewalls of buildings shall comprise at least 15% ventilation of floor areas for windows. Ventilated brickwork or louvers shall not be used where the ingress of driven rain could affect plant or stored materials.

All walkways, staircase, platforms etc., shall be minimum 1200 mm wide and will be provided with SS 304 hand railing on one or both sides as required.

The floor shall generally be made of 150 mm thick concrete slab on grade with 230 mm thick rubble soling and polyethylene sheet. The grade slab shall be provided with TOR 8 mm reinforcement Bars at 200 mm c/c both ways.

All hardware fittings and fixtures for doors, windows and louvers (e.g. Hinges, bolts, locks, latches, stay doorstops, door closers, floor springs) shall be chromium plated brass of heavy type matching to the size and weight of the door/window/ventilator shutters. These shall operate easily without hindrance secure properly without jamming, require nominal maintenance durable under prevailing site/weather conditions.

Suitable steps and/or ramp with overhead RCC Canopy shall be provided as per requirement, at the entrances of the buildings.

1,000 mm wide Plinth Protection (Apron) shall be provided all around the Building/Sheds.

3 EARTHWORK AND EXCAVATION

3.1 Relevant IS Codes

- IS: 1200 : Method of Measurement for Building Works
IS: 3764 : Safety code for Excavation Work
IS: 3385 : Code of practice for measurement of civil engineering works
IS: 2720 : Part II - Determination of Moisture Content
 : Part VII - Determination of Moisture content dry density relation using light compaction
 : Part VIII - Determination of Moisture Content Dry Density using heavy compaction
 : Part XXVIII - Determination of Dry Density of soils, in place, by the sand replacement method
 : Part XXIX - Determination of Dry Density of soils, in place, by the core cutter method.

3.2 Cofferdams:

3.2.1 General Description

This work consists of designing, constructing, maintaining, dewatering, removing, and disposing of cofferdams, which are necessary for constructing substructures and for protecting personnel and adjacent structures, roadbeds, tracks, channels, slopes, or other property (public or private) whether on or off the Rights-of-Way from water, caving soil, and other dangers.

3.2.2 Submittals:

3.2.2.1 Drawings:

The Engineer-in-Charge may require the Contractor to submit drawings of proposed cofferdams for review. If this is required, the Contractor shall not start work until the Engineer-in-Charge completes the review. The review will not relieve the Contractor of the responsibility for providing an adequate and safe cofferdam.

3.2.3 Materials:

Materials used in cofferdam construction may be of any type suitable for the design requirements and for the particular dam being constructed, subject to the Engineer's approval. Earth, sand bags, or dams constructed using excavated materials may be considered for cofferdam construction.

Construction:

3.2.3.1 Designing Cofferdams:

Cofferdams shall be structurally adequate to withstand external and internal forces including the following:

1. Forces and pressures from an excavation depth of not less than 6m
2. Forces and pressures from surcharge loads from adjacent structures, roadbeds, tracks, slopes, and equipment.

Design the cofferdam to meet these conditions:

Cofferdams shall permit placing pumping equipment.

Cofferdams shall permit driving piling between braces.

Cofferdams shall be watertight to permit the construction of substructure.

3.2.3.2 Dewatering Cofferdams without Seal Concrete:

The Engineer shall decide if the Contractor has used all reasonable methods to provide watertight cofferdams. If the enclosures are not dewaterable, and the Engineer shall decide that the Contractor has not used all reasonable methods to provide watertight cofferdams, the Engineer may do either of the following:

Require the Contractor to place Seal Concrete at the Contractor's expense.

Permit the Contractor to place Seal Concrete at the Contractor's expense instead of trying further dewatering methods without a seal.

3.2.3.3 Dewatering Cofferdams with Seal Concrete:

If all reasonable methods to provide a dewaterable enclosure have been used and the Engineer determines that seal concrete is necessary the contractor shall place the concrete. When using seal concrete, the contractor shall dewater the cofferdam no earlier than 24 hours after the concrete is placed unless the Engineer determines that a longer period is necessary.

3.2.4 Removing Cofferdams:

Unless otherwise specified, the contractor shall completely remove all cofferdam material and dispose it off as directed by the Engineer-in-Charge.

3.3 Excavation

3.3.1 Definitions

The following terms shall have the meanings hereby assigned to them:

Top Soil means any surface material, including turf, suitable for use in soiling areas to be grassed or cultivated.

Excavation means excavation in open cut (excluding trench excavation) down to levels required as per approved Drawings or otherwise as being the general levels after completion of excavation.

3.3.2 Site Clearance

All area of the Site, marked in the Specification Drawings shall be cleared to the extent required by the Engineer of all buildings, walls, gates, fence and other structure and obstructions of all bushes, hedges, trees, stumps, roots and other vegetation except for trees marked for preservation. Material so cleared shall so far as suitable be preserved and stacked will be the property of MCGM for further use but shall otherwise be burnt to ash or disposed off the Site as directed by the Engineer-in Charge.

Before starting the work the site shall be cleared of

1. All shrubs, grass, and other vegetation including large and small bushes, all stumps, removal of roots, cutting and disposal of small trees up to 300 mm girth etc.
2. All the trees having girth above 300 mm. (the girth shall be measured at a height of 1.5 m above the ground level) by felling, logging, fashioning of timber and billeting of all branches, trunks etc. including removal of all roots etc. complete as directed.
3. All serviceable reclaimed material shall be stacked separately at the site shown by the Engineer In Charge near the site of excavation and/or transported as directed by Engineer In Charge
4. After the tree is cut and roots taken out the potholes formed shall be filled with good earth in 250mm layers and consolidated unless directed by the Engineer in Charge otherwise. The trees shall be cut in suitable piece as instructed by the Engineer In Charge

3.3.3 General Excavation

1. General excavation means excavation required for structures and from borrow areas, and shall not include trench excavation. General excavation may also include miscellaneous isolated lengths of trenches beneath or adjacent to other structures, trial pits along the structural layout or otherwise.
2. The ground shall be excavated by such methods and to such dimensions and depths as shall allow for the proper construction of the works and safety of personnel and equipment used on excavation. Slopes required for stable formation of sides shall be provided.
3. The excavation in earth, murum, boulders, soft and hard rock shall be carried out to the correct levels required and specified and no tolerance, plus or minus, shall be permitted. However, if any depressions are formed due to removal of boulders, they shall be made good by filling with 1:5:10 concrete up to the bottom layer of the footing/raft.
4. Payment for all types of excavation shall be made by detailed measurement supported by ground levels recorded prior to and after completion of excavation, subject to the limit for payment indicated by the slopes of excavation indicated in the specification drawing. Any additional excavation will be at the contractor's expense, unless specifically approved by the Engineer in-charge.

5. As far as possible excavation should be done by means of mechanical equipment. The bidder should quote accordingly and nothing extra will be paid for mechanical excavation and deployment of extra staff.
6. It will be the responsibility of the contractor to obtain prior permissions from the competent authority to use blasting device, if at all to be resorted to and the license are to be obtained for the same.
7. The chance of blasting required shall be well decided with the expert, to avoid any damage to the surrounding property. However for any such damage to the surrounding property or public or additional excavation shall be the contractor's responsibility and the risks what so ever arising from the same will have to be borne by the contractor.

3.3.4 Lead

Lead for deposition of the excavated materials should be 20km. For the purpose of measurement of lead, the area to be excavated or filled or area in which excavated material is to be deposited /disposed off shall be divided into suitable blocks and for each of the blocks, the distance between centerlines shall be taken as the lead which shall be measured by the shortest straight line route on plan and not the actual route taken by contractor. No extra compensation is admissible on the grounds that the lead including that for borrowed material had to be transported over marshy or kaccha land route.

3.3.5 Excavation in Hard Rock

Excavation in hard rock may be done by blasting / chiseling / breaker machines etc. depending upon the site conditions. When excavation has reached within 300 mm of the required formation level, further excavation shall be carried out carefully either by blasting (if as directed by the Engineer in-charge) or chiseling. Where blasting is resorted to, small charges shall be used to minimize occurrence of heavy over-cuts. The Contractor shall make every effort to carry out the excavation to correct formation level as far as practicable. In order to minimize the over break and loosening of materials at the finished surfaces, final cutting for the last 450 mm to 600 mm in rock shall be carried out by controlled blasting and trimming with the help of pneumatic or other power tools. Unless otherwise specified, the over break shall not exceed 75 mm. The over breakage of 75 mm shall not be measured for payment and therefore the Contractor while quoting his rates for rock excavation has to take this into account. Deduction of 40% or higher percentage as may be desired by the Engineer in-charge shall be made to allow for the voids. Stacks shall not be of width greater than 1.5 m wide or of height less than one meter

1. Blasting shall be carried out by the licensed person only if permitted by the Engineer-in-Charge for which contractor shall obtain the required permission.
2. The Contractor shall provide a method statement and shall comply fully with the requirements of this clause, or any direction, order, requirement or instruction given by the police department or any other relevant authorities as required by the law.
3. Contractor shall submit Blasting plan to the Engineer-in-Charge and take approval for the same on daily basis
4. Contractor shall plan the blasting activities in well advance and convey same to the Project In-charge so as to co-ordinate with all the work groups at site.
5. If blasting is not permitted then contractor shall excavate the rock by manual method without any extra cost.

This includes rock, which is easily excavated by blasting, but due to close proximity of structures or any other reason that the Engineer-in-Charge may consider, will have to be excavated by chiseling.

It should be noted that this clause does not override the Contractor's obligation to satisfy the requirement of the relevant authorities but sets out the extent to which the engineer in charge will exercise his control in approving the Contractor's use of explosive to ensure that explosive are always used in a safe manner. It is the Contractor's sole responsibility to ensure that his method of blasting is safe, that all statutory and imposed limitation is adhered to, and to obtain a permit to use explosive from the relevant authorities and to comply with the condition of issue of the permit.

The Contractor shall be solely responsible for obtaining the necessary licenses for the procurement, possession, transport, storage and handling of explosive and for ensuring the validity of such licenses at all times. Before starting work, the Contractor shall satisfy the engineer that all the requirement permits are in order and that this category of work is adequately covered in the policies of insurance.

Explosives shall be used in the quantities and manner recommended by the manufacturers. All necessary precautions shall be taken to preserve the materials below in the soundest possible condition and also beyond the lines of all excavations.

Blasting by means of drill holes, tunnels or any other similar method shall be the responsibility of the Contractor.

The Contractor shall take all the necessary precautions during blasting operations to ensure that no injure is caused to persons or damage to property or to the finished works. Shots shall be properly loaded and capped and only appropriate charges shall be used in each hole.

3.3.5.1 Storage and Transport

Proper building for storage of magazines of explosives, with separate compartment for detonators in suitable positions in the manner and quantities to be approved, shall be provided. Separate vehicles or vessels for detonators shall also be used for the transportation of explosives. The prevention of any unauthorized issue or improper use of any explosive brought on to the site shall be the responsibility of the Contractor and only experienced licensed short firers shall be employed to handle the explosive for the purpose of the work the relevant security regulations dealing with the storage, handling and transport of explosives shall be complied with.

3.3.5.2 Safety

The Contractor shall provide an approved system of warning and preparing the general public and all site personnel of an impending blast by both audible & visual means and shall ensure that the blasting area is cleared of all personnel immediately prior to blasting. This system shall comply with all statutory requirements. The Contractor's attention I drawn to the need

3.3.6 Excess excavation to be made good

The contractor, at his own expense, shall, if directed, remove from the Site all excess material resulting from excess excavation and shall make good the same with such kind of fill material or in such class of concrete as may be reasonably required by the Engineer-in Charge having regard to the circumstances.

3.3.7 Stripping Top Soil

Where ordered by the Engineer in-charge, topsoil shall be stripped to such depths and over such areas as he may direct, as a separate operation prior to any further excavation, which may be required.

3.3.8 Supporting Excavations

The Contractor shall properly support the sides and ends of all excavations to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation. Any excavation necessary to provide space for such support or other working space shall be carried out. If, for any reason, any portion of the bottoms, sides or ends of any excavations shall give way, the contractor shall at his own expense take all necessary remedial measures including the extra necessary excavation and removal of excess material.

Where the Contractor proposes and is permitted by the Engineer in-charge to perform excavations with sloping faces (other than sloping excavations shown on the Drawings or required as permanent features of the Works) and without shoring, the excavated faces shall be to stable slopes and heights.

3.3.9 Trimming Excavations

When excavating to specified or required levels for the foundation of any structure or to specified or required limits for the face of any structure required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing the constructional work, except where the Engineer-in Charge shall permit otherwise. After getting the permission for the commencement of the construction, if the contractor delays on any account & the formation level gets damaged he will have to do further excavation up to 150mm or as per engineer in-charge's instructions at his own account.

Before commencement of any constructional work all shattered and loose materials shall be removed from the excavations by hand so as to ensure that the work rests on a solid and perfectly clean foundation or abuts against solid ground.

3.3.10 Inspection by the Engineer-in-Charge

When the specified levels or limits of excavation are reached the Engineer-in-Charge will inspect the ground exposed, and if he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, selected excavated material or selected imported material as directed by the Engineer-in-Charge.

Should the material forming the bottom of any excavation, while acceptable to the Engineer-in-Charge at the time of his inspection, subsequently become unacceptable to him due to exposure to weather conditions or due to flooding or have puddles, soft or loss during the

progress of the works, the Contractor shall remove such damaged, softened or loosened material and excavate without any extra cost.

3.3.11 Disposing Excavated Material

All excavated material shall remain the property of the MCGM. The Contractor shall ensure that no excavated material, which is suitable for and is required for re-use in the Works is transported unless, so ordered by the Engineer-in-Charge. All surplus and excavated earth and other debris including construction debris, deposits, large / small sized floating and suspended material collected from the silt pit and from area in front of the screen, removed screenings etc. shall be collected, removed and transported by the Contractor in accordance with MCGM's debris management plan to any specified location / dumping ground as directed by Engineer. Contractor to note that no separate payment will be made for these works.

3.3.12 Back-Filling General Site Grading and Sand Filling

3.3.12.1 Fill Material

1. All fill material shall be murum free from rock or any such hard material that will obstruct the piling operation. Whether such material is brought from outside borrow areas or obtained from excavation within the site, will be subject to Engineer-in-Charge's approval. Notwithstanding any approval given to the fill material or borrow areas from which fill material is proposed to be brought, the Engineer-in-Charge reserves the right to reject such material which in his opinion either does not meet the specification requirements or unsuitable for the purpose for which it is intended.
2. Roads, of a temporary nature, required to be constructed for access and for movement of men, materials, equipment, transport vehicles, vehicles carrying fill material, etc. to or over borrow areas and or to or over areas on which fill has to be deposited shall be constructed by the Contractor. Such access roads shall be maintained in good condition during all seasons to ensure completion of the work according to the time schedule. No separate payment shall be made for such items of work.

3.3.12.2 Backfilling

1. Excavated material used as back filling to excavations or completed structures shall be free from rubbish, vegetation, clods and lumps and shall be approved by the Engineer-in-Charge. The approved materials shall be placed in layers, not exceeding 150 mm in depth before compaction and shall be compacted with watering, consolidating and ramming.
2. Soft material shall not be used as back filling around structures in rock. The Contractor shall backfill such excess excavation with concrete, rubble, stone or rock fill as directed by the Engineer-in-Charge. Filling other than concrete shall be placed in layers not exceeding 150 mm in thickness, shall be thoroughly compacted and have adequate fined content to fill the voids.
3. Should the material being placed as back filling, while acceptable at time of selection, become unacceptable to the Engineer-in-Charge due to exposure to weather conditions or due to flooding or have become puddles, soft or segregated during the progress of

the works, the Contractor shall remove such damaged, softened or segregated material and replace it with fresh approved material at his expense.

4. The Contractor shall while placing the back filling make due allowance for any settlement that may occur before the end of the Defects Liability Period, remove any excess material or make up any deficiency by back filling to the specified levels. As a rule material to be back filled shall be stacked temporarily at a suitable place.
5. General Site Grading: Site grading shall be carried out as directed by the Engineer-in-Charge. Excavation shall be carried out as specified in the specification. Filling and compaction shall be carried out as specified under (6) of this Clause unless otherwise indicated below.
6. The approved material shall be placed in layers not exceeding 150 mm in depth before compaction and shall be compacted.
7. 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 should remove the affected materials and make good the slip without any extra cost.
8. The fill shall be carried out to such dimensions and levels as directed by the Engineer in-charge, after the compaction.
9. Sand filling below Plinth and other places

Back filling shall be carried out with sand at places as directed by the Engineer in -Charge. The sand used 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. Any temporary work required to contain sand under flooded conditions shall be to the Contractor's account. The surface of the consolidated sand shall be dressed to the required level or slope. Construction of floors or other structures on sand fill shall not be started until the Engineer-in-Charge has inspected and approved the fill.

Where specified in the schedule of works, compaction of the plinth fill shall be carried out by means of 12 tonne rollers smooth wheeled, sheep foot or wobbly-wheeled rollers. A smaller weight roller may be used only if permitted by Engineer. As rolling proceeds water sprinkling shall be done to assist consolidation. Water shall not be sprinkled in case of sandy fill.

The thickness of each unconsolidated fill layer can in this case up to 300 mm. Engineer in charge will determine the thickness of layers in which fill has to be consolidated depending on the fill material and equipment used.

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

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

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

3.3.13 Fill Density

The compaction, only where so called for, in the schedule of quantities /items shall comply with the specified (proctor/modified proctor) density at moisture content differing not more than 4 percent from optimum moisture content. Contractor shall demonstrate adequately at his cost, by field and laboratory tests that the specified density had been obtained.

3.3.14 Local Rules and Regulations

1. The Contractor shall familiarize himself with the local rules and regulations governing the excavation, quarrying operations, etc. and the work shall be carried out strictly in accordance with rules and regulations, if any. Whenever a quarry is required to be opened in connection with the execution of work covered under this Contract, the Contractor shall investigate that it shall yield stones and other materials such as sand, murum, soil etc. of approved quality and shall satisfy himself as to the availability in desired quantity. He shall supply necessary quantity of sand, stone, metal aggregate etc. to the Engineer-in-Charge for carrying out tests as desired by the Engineer-in-Charge and well in advance of its use so as to carry out tests and to get approval. The cost of opening and operating the quarry & royalties and ant other charges shall be borne entirely by the Contractor.
2. The Contractor shall obtain necessary permission from the concerned authorities before opening the quarry. In case of quarries in private land on payment of whatever charges as may be due to the owner.

3.4 Dewatering

- a. All excavations shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Contractor shall remove by pumping or other means approved by Engineer-in-Charge any water inclusive of rain water and sub-soil water accumulated in excavation and keep all excavations de-watered until the foundation work is completed and back filled. Sumps made for dewatering must be kept clear of the excavations/trenches required for further work. Method of pumping shall be approved by Engineer-in-Charge; but in any case, the pumping arrangement shall be such that there shall be no movement of sub-soil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.
- b. When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of Engineer, as large, well point system: Single-stage or Multi-stage shall be adopted. Contractor shall submit to the Engineer in charge his scheme of well pointing system including stages, the spacing, number and diameter of well points, headers etc. and the number, capacity and location of pumps for approval.
- c. The rates for excavation are inclusive of dewatering by any means and no extra payment is allowed for excavation in wet condition.

3.5 Timber Shoring

The Timber Shoring shall be as per 3764-1966 safety code for excavation work

- a. Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. 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 wailings of strong wood at maximum 1.2 m spacing and suitably strutted. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported by vertical wailings, 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.
- b. The shoring material shall not be sizes less than those specified below unless steel sheet piling is used or unless otherwise approved by the Engineer-in-Charge in writing:

Planks	-	5 cm x 25 cm
Waling pieces	-	10 cm x 20 cm
Struts	-	15 cm x 20 cm

- c. 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 Engineer-in-Charge. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of excavations, trenches, pits, etc., from collapsing.
- d. Timber shoring may 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 Engineer-in-Charge.
- e. The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started at one end and preceded systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber, which cannot be retrieved.
- f. 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 5 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 spacing shall be subject to the approval of the Engineer-in-Charge. In all other respects, the specification for close timbering shall apply to open timbering.
- g. 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. Load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut.
- h. In addition to the above, MS shoring is also acceptable.

3.6 Rain Water Discharge

3.6.1 Scope

The scope covers the drainage of rainwater in excavated areas.

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 at no extra cost to the Owner. The scheme for pumping and discharge of such water shall be approved by the Engineer-in-Charge.

4 CONCRETE AND ALLIED WORKS

4.1 General

- a. The quality of materials and method and control of manufacture and transportation of all concrete work irrespective of mix, whether reinforced or otherwise shall conform to the applicable portions of this specification.
- b. The Engineer in-charge shall have the right to inspect the source/s of material/s, the layout and operation of procurement and storage of materials, the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged and Engineer-in-Charge's approval obtained, prior to starting of concrete work. However, this shall not relieve the contractor with any of his responsibilities and all the materials, which do not conform to the specifications, will be rejected.
- c. The liquid retaining structures shall be constructed in minimum concrete grade of M40
- d. The Contractor will maintain a register for quantity of steel consumed and concreting done updated on daily basis.

4.2 Applicable Codes

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

MATERIALS

1. IS:269 - Specification for 33 grade ordinary Portland cement
2. IS: 455 - Specification for Portland slag cement.
3. IS: 8112 - Specification for 43-grade ordinary Portland cement.
4. IS: 12330 - Specification for sulphate resisting Portland cement.
5. IS: 383 - Specification for coarse and fine aggregates from natural sources for concrete.
6. IS: 432 - Specification for mild steel and medium tensile steel (Parts-I & II) bars and hard-drawn steel wires for concrete reinforcement.
7. IS: 1786 - Specification for high strength deformed steel bars and wires for concrete reinforcement.
8. IS: 1566 - Specification for hard-drawn steel wire fabric for (Part-I) concrete reinforcement.
9. IS: 9103 - Specification for admixtures for concrete.
10. IS: 2645 - Specification for integral cement waterproofing compounds.
11. IS: 4990 - Specification for plywood for concrete shuttering work.

MATERIAL TESTING

1. IS: 4021 - Methods of physical tests for hydraulic cement. (Parts-1 to 13)
2. IS: 4032 - Method of 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-I to VIII)
6. IS: 3025 - Methods of sampling and test (physical and chemical) water used in industry.
7. IS: 6925 - Methods of test for determination of water-soluble chlorides in concrete admixtures.

MATERIALS STORAGE

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

CONCRETE MIX DESIGN

1. IS: 10262 - Recommended guidelines for concrete mix design.
2. SP: 23 - Handbook on Concrete Mixes. (S & T)

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.

EQUIPMENT

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.

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-I to IV)
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 building.
13. IS: 4326 - Code of practice for earthquake resistant construction of building.
14. IS:4014 - Code of practice for steel tubular scaffolding.(parts-I & II)
15. IS: 2571 - Code of practice for laying in-situ cement concrete flooring.
16. IS: 7861 - Code of practice for extreme weather concreting.
Part-I: Recommended practice for hot weather concreting.
Part-II: Recommended practice for cold weather concreting.
17. IS: 13920 - Ductile Detailing of Reinforced Concrete Structure subjected to 1993 seismic forces.
18. SP-16 - Design Aids for Reinforcement Concrete to IS:456-1978(S&T) - 1980
19. SP-24 - Explanatory Handbook on IS:456-1978
20. SP-34 - Handbook on Concrete Reinforcement and Detailing (S&T) - 1987

CONSTRUCTION SAFETY

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

MEASUREMENT

1. IS: 1200 - Method of measurement of building and engineering works.
2. IS: 3385 - Code of practice for measurement of civil engineering works.

4.3 Materials for Standard Concrete

The ingredients to be used in the manufacture of concrete shall consist solely of Ordinary Portland Cement with GGBS or Portland slag cement, clean sand, natural

coarse aggregate, clean water and admixtures if specifically called for on conditions at site warrant its use.

Cement

- i) The contractor will have to make his own arrangements for procuring cement and steel.
- ii) The Contractor will have to make his own arrangements for transport from supplier godown and storage of adequate quantity of cement. Contractor will construct cement godown at site as per MCGM rules. Cement in bulk may be stored in bins or silos, in batches of 10x10, which will provide complete protection from dampness, contamination and minimize caking and false set. Cement bags shall be stored in a dry enclosed shed (storage under tarpaulins will not be permitted), well away from the outer walls and insulated from the floor to avoid contact with moisture from the ground and so arranged as to provide ready access. Damaged or reclaimed or partly set cement will not be permitted to be used and shall be removed from the site. The storage bins and storage arrangement shall be approved by the Engineer-in-Charge. Consignments of cement shall be stored as received and shall be consumed in the order of their delivery.
- iii) Cement held in storage for a period of ninety (90) days or longer shall be tested. Should at any time the Engineer-in-Charge have reasons to consider that any cement is defective, then irrespective of its origin, date of manufacture and or manufacturer's test certificate, such cement shall be tested immediately at the Contractor's cost at an approved laboratory and until the results of such tests are found satisfactory, it shall not be used in any work. Testing certificates for each batch of cement should be submitted by the contractor to the Engineer in charge, before starting the concreting work. The Contractor shall not be entitled to any claim of any nature on this account.

Aggregates

- i) General

"Aggregate" in general designates both fine and coarse inert materials used in the manufacture of concrete (Vide BIS 456 & BIS 383) and confirming to tests as per BIS 2386 (Part I to VI)

"Coarse Aggregate" is aggregate most of which is retained when passed through on 4.75 mm BIS sieve.

All fine and coarse aggregates proposed for use in the works shall be subject to the Engineer-in-Charge's approval and after specific materials have been accepted, the source of supply of such materials shall not be changed without prior approval of the Engineer-in-Charge.

Aggregates shall consist of natural sands, stone (crushed or uncrushed) and gravel from a source known to produce satisfactory aggregate for concrete and shall be chemically inert, non-flaky, strong, hard, durable against weathering, of limited porosity and free from deleterious materials that may cause corrosion of the reinforcement or may impair

the strength and or durability of concrete. The grading of aggregates shall be such as to produce a dense concrete of specified strength and consistency that will work readily into position without segregation and shall be based on the "mix design" and preliminary tests on concrete specified later.

ii) Sampling and testing

Samples of the aggregates for mixed design and determination of suitability shall be taken under the supervision of the Engineer in-charge and delivered to the laboratory, well in advance of the scheduled placing of concrete. Records of tests, which have been made on proposed aggregates and on concrete made from this source of aggregates shall be furnished to Engineer in-charge in advance of the work, for use in determining aggregate suitability. The costs of all such tests, sampling etc. shall be borne by the contractor.

iii) Storage of aggregates

All coarse and fine aggregates shall be stacked separately in stock piles in the material yard near the work site in bins properly constructed to avoid inter mixing of different aggregates. Contamination with foreign material and earth during storage and while heaping the materials shall be avoided. The aggregates must be of specified quality not only at the time of receiving at site but more so at the time of loading into mixer. Rakers shall be piled in layers not exceeding 1.20 m in height to prevent coning or segregation. Each layer shall cover the entire area of stockpile before succeeding layers are started. Aggregates that have become segregated shall be rejected.

iv) Specific Gravity

Aggregates having a specific gravity below 2.4 (saturated surface dry basis) shall not be used.

4.4 Fine Aggregate

Fine aggregate shall consist of natural or crushed sand conforming to BIS 383 confirming to tests as per BIS 2386 part I to VI. The sand shall be clean, sharp, hard, strong and durable and shall be free from dust, vegetable substances, adherent coating, clay, alkali, organic matter, mica, salt, or other deleterious substances, which can be injurious to the setting qualities/strength/durability of concrete.

Screening and Washing: Sand shall be prepared for use by such screening or washing, or both, as necessary, to remove all objectionable foreign matter while separating the sand grains to the required size fraction.

- a) Foreign Material limitations : The percentage deleterious substances in sand delivered to the mixer shall not exceed the following:

Table 2 : Foreign Material Limitations in Fine Aggregate

Sr.	Foreign material	Percentage by weight	
		Uncrushed	Crushed
1	Material finer than 75 micron BIS sieve	3.0	15.0
2	Shale	1.0	-
3	Coal & Lignite	1.0	1.0
4	Clay Lumps	-	1.0
	Total	5.0	17.0

- b) Gradation: Unless otherwise directed or approved by the Engineer-in-Charge, the grading of sand shall be within the limits indicated hereunder:

Table 3 : Grading of Sand for Fine Aggregate

Sr.	BIS :Sieve Designation	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
1	10 mm	100	100	100	100
2	4.75 mm	99-100	90-100	90-100	95-100
3	2.36 mm	60-95	75-100	85-100	95-100
4	1.18 mm	30-70	55-90	75-100	90-100
5	600 microns	15-34	35-59	60-79	80-100
6	300 microns	5-20	8-30	12-40	15-50
7	150 microns	0-10	0-10	0-10	0-15

Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 microns IS sieve, by total amount not exceeding 5%, it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron IS sieve or to percentage passing any other sieve on the coarser limit of grading zone I or the finer limit of grading zone IV. Fine aggregates conforming to grading zone IV shall be used. Mix designs and preliminary tests shall show its suitability for producing concrete of specified strength and workability.

- c) Fineness Modulus

The sand shall have a fineness modulus of not less than 2.2 or more than 4.2. The fineness modulus is determined by adding the cumulative percentages retained on the following IS sieve sizes (4.75 mm, 2.36 mm, 1.18 mm, 600 microns and 150 microns) and dividing the sum by 100.

4.5 Coarse Aggregate

- a) Coarse aggregate for concrete, except as noted above, shall conform to IS 383 & IS 2386. This shall consist of crushed stone and shall be clean and free from elongated, flaky or laminated pieces, adhering coatings, clay lumps, coal residue, clinkers, slag, alkali, mica, organic matter or other deleterious matter.

- b) Screening and Washing: Crushed rock shall be screened and or washed for the removal of dirt or dust coating, if so requested by the Engineer in-Charge.
- c) Grading
- i) Coarse aggregate shall be either in single size or graded, in both cases the grading shall be within the following limits:

BIS Sieve Size (mm)	Percentage passing for single sized aggregate of normal size					Percentage Passing For Graded Aggregate Of Normal Size			
	40 mm	20 mm	16 mm	12.5 mm	10mm	40 mm	20 mm	16 mm	12.5 mm
63	100	-	-	-	-	100	-	-	-
40	85-100	100	-	-	-	95-100	-	-	-
20	0-20	85-100	100	-	-	30-70	95-100	100	-
16	-	-	85-100	100	-	-	-	90-100	-
12.5	-	-	-	85-100	100	-	-	-	90-100
10	0-5	0-20	0-30	0-45	85-100	10-35	25-35	30-70	40-85
4.75	-	0-5	0-5	0-10	0-20	0-5	0-10	0-10	0-10
2.36	-	-	-	-	0-5	-	-	-	-

- ii) The pieces shall be angular in shape and shall have granular or crystalline surfaces. Friable, flaky and laminated pieces, mica and shale, if present, shall be only within tolerance limits, which will not affect adversely the strength and or durability of concrete. The maximum size of coarse aggregate shall be 40 mm for M-7.5 and M-10 and 20mm for M-15 to M-20 concrete, or as directed by the Engineer-in-Charge or specified otherwise. The maximum size of coarse aggregate shall be the maximum size specified above but in no case greater than 1/4th of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form. For plain concrete the maximum size of aggregate shall be of 40 mm. For heavily reinforced concrete members, the nominal maximum size of the aggregate shall be 5 mm less than the minimum clear distance between the reinforcing main bars or 5 mm less than the minimum cover to reinforcement whichever is smaller.
- d) Foreign material limitations:
 The percentage of deleterious materials in the aggregate delivered to the mixer shall not exceed the following:

Table 4 : Foreign Material Limitations in Coarse Aggregate

Sr.	Foreign Material	Percentage by weight	
		Uncrushed	Crushed
1	Material finer than 75 micron BIS Sieve	3.0	3.0
2	Coal and lignite	1.0	1.0
3	Clay Lumps	1.0	1.0
4	Soft Fragments	3.0	-
	Total	8.0	5.0

4.6 Water

- a) Water used for washing, mixing and curing shall be free from injurious amounts of deleterious materials. Potable water is generally satisfactory for mixing and curing concrete. Physical and chemical analysis of the water should be submitted to the Engineer-in-Charge, before starting the work.
- b) In case of doubt, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time test specified in BIS 456. The sample of water taken for testing shall be typical of the water proposed to be used for concreting, due account being paid to seasonal variation. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water.
- c) Average 28 days compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of BIS 516.
- d) The initial setting time of test block must be made with the appropriate test cement and the water proposed to be used. It shall not be less than 30 minutes and shall not differ by more than +/-30 minutes from the initial setting time of control test block prepared with the appropriate test cement and distilled water. The test block shall be prepared and tested in accordance with the requirements of BIS 4031.
- e) Where water can be shown to contain an excess of acid, alkali, sugar or salt, Engineer-in-Charge may refuse to permit its use. As a guide, the following concentrations represent the maximum permissible values.
 - 1) To neutralize 200 ml sample of water, using phenolphthalein as indicator, it should not require more than 2 ml of 0.1 normal NaOH. The details of test shall be as given in BIS 3025.
 - 2) To neutralize 200 ml sample of water, using methyl orange as an indicator, it should not require more than 10 ml of 0.1 Normal HCl. The details of test shall be as given in BIS 3025.

- 3) Percentage of solids, when tested in accordance with the method indicated below shall not exceed the following:

Solids	Percent	Method of test
Ref. to col. no in IS:3025) Organic (organic solid = total solids minus ignited residue)	0.02	10 and 11
Inorganic	0.03	11(ignited residue)
Sulphates (as SO_4)	0.05	20
Alkali Chlorides (as Cl)	0.20	24
Suspended matter	0.20	12
The pH value of water shall not generally be less than 6.		

4.7 Steel and Aluminium Members Encased in Concrete

Structural steel and aluminum ladders etc. to be encased in concrete shall be without paint. Primer should be used for encasing purpose. The encasing shall be done in concrete with 10 mm, maximum size aggregate and a works cube strength not less than 150 kg/sq.cm. at 28 days unless otherwise specified. The member shall be wrapped with galvanized aluminum wire mesh of adequate size. The galvanized aluminum wire mesh shall be kept 20 mm from the edge or surface of the member and shall be held in position securely. The member will have a minimum cover of 50 mm unless otherwise indicated in the drawings. Where the clear cover is more than 75 mm, concrete with 20 mm coarse aggregate can be used.

4.8 Mix Design

4.8.1 General

This is essential for investigating the grading of aggregates, water-cement ratio, workability and the quality of cement required to give preliminary and works cubes of the minimum strength specified. The proportions of the mix shall be determined by weight. Adjustment of aggregate proportions due to moisture present in the aggregate shall be made. Determination of mix proportions shall be carried out according to "Recommended guidelines for Concrete Mix Design" conforming to IS:10262.

Whenever there is a change either in required strength of concrete, or water-cement ratio or workability or the source of aggregates and/or cement, preliminary tests shall be repeated to determine the revised proportions of the mix to suit the altered conditions. While designing proportions, over-wet mixes shall always be avoided.

While fixing the value for water/cement ratio for preliminary mixes, assistance may be derived from the graph (Appendix A, BIS 456 showing the relationship between the 28 day compressive strengths of concrete mixes with different water/cement ratios and the 7-day compressive strength of cement tested in accordance with IS:269.

4.8.2 Preliminary Tests

Test specimens shall be prepared with at-least two different water/cement ratios for each class of concrete, consistent with work ability required for the nature of the work. The materials and proportions used in making preliminary tests shall be similar in all respects to those to be actually employed in the works as the object of these tests is to determine the properties of cement, aggregates and water necessary to produce concrete of required consistency and to give the specified strength, it will be contractor's sole responsibility to carry out these tests and he shall therefore furnish to Engineer-in-Charge a statement of proportions proposed to be used for the various concrete mixes. For preliminary tests, the following procedure shall be followed.

Materials shall be brought to the room temperature and all materials shall be in a dry condition. The quantities of water cement and aggregate for each batch shall be determined by weight to an accuracy of 1 part in 100 parts.

Mixing concrete shall be done by hand (for small quantities, as directed by Engineer-in-Charge) or in a small batch mixer as per IS: 516 in such a manner as to avoid loss of water. The cement and fine aggregate shall first be mixed dry until the mixture is uniform in color. The coarse aggregate shall then be added, mixed and water added and the whole batch mixed thoroughly for a period of not less than two minutes until the resulting concrete is uniform in appearance. Each batch of concrete shall be such a size as to leave about 10% excess concrete, after moulding the desired number of test specimens.

The consistency of each batch of concrete shall be measured immediately after mixing, by the slump test in accordance with IS: 1199. If in the slump test, care is taken to ensure that no water or other material is lost, the material used for the slump test may be re-mixed with the remainder of the concrete for making the specimen test cubes. The period of re-mixing shall be as short as possible yet sufficient to produce a homogeneous mass.

The samples for compression tests of concrete shall be made as per IS: 516 on 15 cm cubes. Each mould shall be provided with a metal base plate having a plate surface so as to support the mould during filling without leakage. The base plate shall be preferably attached to the mould by springs or screws. The parts of the mould when assembled shall be positively and rigidly held together. Before placing concrete, the mould and base plate shall be cleaned and oiled. The dimensions and internal faces of the mould shall be accurate within the following limits. Height and distance between the opposite faces of the mould shall be of specified size ± 0.2 mm. The angle between the adjacent internal faces and between internal faces and top and bottom faces of mould shall be 90-degree ± 0.5 degree. The interior faces of the mould shall be plane surfaces with a permissible variation of 0.03 mm.

Concrete test cubes shall be moulded by placing fresh concrete in the mould and compacted as specified in IS 516.

Curing shall be as specified in IS 516. The cubes shall be kept in moist air of at least 90% relative humidity at a temperature of 27 degree C ± 2 degree C for 24 hours ± 2 hours from the time of adding water to the dry ingredients. Thereafter they shall be removed from the moulds and kept immersed in clean, fresh water and kept at 27 degree C ± 2 degree C temperature until required for test. Curing water shall be renewed every seven days. A record of maximum and minimum temperatures at the

place of storage of the cubes shall be maintained during the period they remain in storage.

The strength shall be determined based on not less than five cube test specimens for each age and each water cement ratio. All these laboratory test results shall be tabulated and furnished to the Engineer-in-Charge. The test results shall be accepted by the Engineer-in-Charge if the average compressive strengths of the specimens tested is not less than the compressive strength specified for the age at which specimens are tested subject to the condition that only one out of the five consecutive tests may give a value less than the specified strength for that age. The Engineer-in-Charge may direct the contractor to repeat the tests if the results are not satisfactory and also make such changes as he considers necessary to meet the requirements specified. All these preliminary tests shall be conducted by the contractor at his own cost in an approved laboratory or in laboratory of MCGM.

4.9 Proportioning, Consistency, Batching and Mixing of Concrete

The determination of the water cement ratio and proportion of aggregates to obtain the required strength shall be made from preliminary tests by designing the concrete mix. Controlled concrete shall be used on all concrete work complying with all the requirements of IS: 456. Cube tests shall be carried out by the contractor on the trial mixes before the actual concreting operation starts. Based on the strength of the concrete mix sanction for the use has to be obtained from engineer in charge.

If during the execution of the works it is found necessary to revise the mix because of the cube tests showing lower strengths than the required one due to inconsistency of quality of material or otherwise, The Engineer in charge shall ask for fresh trial mixes to be made by the contractor. No claim to alter the rates of concrete work shall be entertained due to such change in mix variations as it is the contractor's responsibility to produce the concrete of the required grade.

Great care shall be exercised when mixing the actual works concrete using the proportions of the selected trial mix. The final concrete mix shall have the same proportions of cement, fine and coarse aggregates and water as that of the approved selected mix.

A reasonable number of bags should be weighed separately to check the Net weight, where the weight of cement is determined by accepting the manufacturer's weight per bag at the site. Proper control of mixing water is deemed to be of paramount importance. If mixers with automatic addition of water are used, water should be either measured by volume in calibrated buckets, tins or weighed. All measuring equipment shall be maintained in a clean serviceable condition and their accuracy periodically checked and certified and the Engineer-in-Charge's approval obtained.

The Engineer-in-Charge may require the contractor to carry out moisture content tests in both fine and coarse aggregates. The amount of the added water shall then be adjusted to compensate for any observed variations in the moisture contents. BIS: 2386 shall be referred to for determination of moisture content.

No substitution in material, used on the work or alteration in the established proportions shall be made without additional tests to show that the quality and strength of concrete

are satisfactory. No alterations shall be permitted without the prior sanction of the Engineer-in-Charge.

4.9.1 Mixing of Concrete

The mixing of concrete shall be strictly carried out in an approved type of Batching & Mixing Plant for Concrete. Ready Mix Concrete as per IS 4926-1976 shall be used for which Concrete Batching Plant should be provided at site. The Concrete Batching Plant shall be fully computerised. The Concrete Batching Plant shall have a Capacity of 30 Cum/Hr. Minimum Four Transit Mixer shall be provided with Concrete Pumps along with line pumps for ready mix concrete. Fully equipped Quality Assurance Laboratory shall be provided and following tests shall be done:

- Equipment Tests
- Calibration of Electronic Load Cell (Weigh Batcher)
- Calibration of Water Meter.
- Calibration of Admixture Dispenser
- Calibration of Cube Testing Machine.

For small concreting works, mechanical concrete mixers may be used. The entire batch shall be discharged before recharging. Mixing periods shall be measured from the time when all of the solid materials are in the mixing drum, provided that all of the mixing water shall be introduced before one fourth of the mixing time has elapsed. The mixing time in no case shall be less than two minutes. The mixer speed shall not be less than 14 nor more than 20 revolutions per minute. Mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in color and consistency. Hand mixing of concrete shall not be permitted at all.

4.9.2 Grade of Concrete

The different grades of concrete specified shall conform to the strengths as required by IS:456-2000. Standard deviation shall be calculated as stated in 9.24 of IS:456-2000. The acceptable criteria for concrete shall be as stated in IS:456 -2000. The assumed standard deviations as given in table 8 of IS:456-2000 have to be followed and are given here under. However, the minimum cement content shall be as per *Table no. 7: Minimum Cement Content in Concrete* in this tender document.

Table 5 : Grade of Concrete

Grade of Concrete	Assumed Standard Deviation N/sq.mm
M 15	3.5
M 20	4.0
M 25	4.0
M 30	5.0
M 35	5.0
M 40	5.0

4.9.2.1 Controlled Concrete

Controlled concrete shall be used on all concreting works except where specified otherwise the mix proportions for all grades of concrete shall be designed to obtain strengths corresponding to the values specified in table below for respective grades of concrete.

Table 6 : Compressive Strengths at 28 days

Grade	Specified Characteristic Compressive Strength at 28 days (N/sq.mm)
M15	15
M20	20
M25	25
M30	30
M35	35
M40	40

The maximum Water : Cement ratio for all controlled concrete works shall be as specified in IS:456-2000 as Preliminary tests as specified in the BIS code and required by the Engineer-in-Charge shall be carried out sufficiently ahead of the actual commencement of the work with different grades of concrete made from representative samples of aggregates and cement expected to be used on the job to ascertain the ratios by weight of cement of total quantity of fine and coarse aggregates and the water cement ratio required to produce a concrete of specified strength and desired workability.

The minimum cement content for each grade of concrete shall be as per table below.

Table 7 : Minimum Cement Content in Concrete

Grade of Concrete	Minimum Cement Content in Concrete (kg/cum of finished Concrete)
M 15	330
M 20	360
M 25	410
M 30	430
M 35	440
M 40	450

At least 4 (four) trial batches are to be made and 7 test cubes should be taken for each batch noting the slump on each mix. These cubes shall then be properly cured and two cubes for each mix shall be tested in a testing laboratory approved by the Engineer-in-Charge at 7 days and others at 28 days for obtaining the ultimate compressive strength. The test reports shall be submitted to the Engineer in charge. The cost of mix design and testing shall be borne by the contractor. On the basis of the preliminary test reports for trial mix, a proportion of mix by weight and water cement ratio will be approved by the Engineer in charge, which will be expected to give the required strength.

Consistency and workability and the proportions so decided for different grades of concrete shall be adhered to during all concreting operations. If however at any time the Engineer-in-Charge feels that the quality of material, being used has been changed from those used for preliminary mix design, the contractor shall have to run similar trial mixes to ascertain the mix proportions and consistency.

The mix once approved must not be varied without prior approval of the Engineer-in-Charge. However should the contractor anticipate any change in the quality of future supply of materials than that used for preliminary mix design, he shall inform the same to the Engineer-in-charge and bring fresh samples sufficiently ahead to carry out fresh trial mixes. The engineer in charge shall have access to all places and laboratory where design mix is prepared. Design mix will indicate by means of graphs and curves etc. the extent of variation in the grading of aggregates, which can be allowed.

In designing the mix proportions of concrete, the quantity of both cement and aggregate shall be determined by weight. All measuring equipment shall be maintained in clean and serviceable condition and their accuracy periodically checked.

To keep the water cement ratio to the designed value, allowance shall be made for the moisture contents in both fine and coarse aggregates and determination of the same shall be made as frequently as directed by the Engineer-in-Charge. The determination of moisture contents shall be according to IS:2386 (Part III).

Durability test of concrete such as water permeability (as per IS 3085), water absorption (BS 1881-122:1983) and rapid chloride penetration test (as per ASTM C1202-2012) should be done on concrete during trial mix. Chloride permeability should be moderate as per ASTM C1202.

4.9.2.2 Strength Requirements

All concrete in the works shall be "Controlled Concrete" as defined in IS: 456 except for M-7.5 and M-10 for which normal mix concrete shall be used.

Where ordinary Portland cement conforming to IS: 269 or Portland blast furnace slag cement conforming to IS: 455 is used the compressive strength requirements for various grades of concrete shall be as shown in table below. Where rapid hardening Portland cement is used the 28 days compressive strength requirements specified in Table-hereunder shall be met in 7 days. The strength requirements specified in table shall apply to both controlled concrete and ordinary concrete.

Minimum Compressive Strength Of 15 cm cubes at 7 days and 28 days after mixing, conducted in accordance with IS: 516.

Class	Preliminary Test N/mm²		Works Test N/mm²		Maximum Size Of Aggregate mm	Locations For Use
	At 7 Days	At 28 days	At 7 days	At 28 days		

Class	Preliminary Test N/mm²		Works Test N/mm²		Maximum Size Of Aggregate mm	Locations For Use
	At 7 Days	At 28 days	At 7 days	At 28 days		
M40	33.5	50.0	27.0	40.0	20	As indicated in the specifications or as required
M35	30.0	44.0	23.5	35.0	20	-do-
M30	25.0	38.0	20.0	30.0	40 or 20	-do-
M25	22.0	32.0	17.0	25.0	40 or 20	-do-
M20	17.5	26.0	13.5	20.0	40 or 20	-do-
M15	13.5	20.0	10.0	15.0	40 or 20	-do-

Note: It shall be very clearly understood that whenever the grade of concrete such as M-20, etc. is specified it shall be contractor's responsibility to ensure the minimum crushing strength stipulated for the respective grade of concrete is obtained at works.

Other requirements of concrete strength as may be desired by the Engineer in charge shall be in accordance with Indian Standard BIS:456 (latest revision). The acceptance of strength of concrete shall be as per "Sample size and Acceptance Criteria" of IS:456 (latest revision) subject to stipulation and/or modifications stated elsewhere in this specification if any.

Concrete work found unsuitable for acceptance shall have to be dismantled and replaced to the satisfaction of the engineer in –charge by the contractor free of cost of the owner. No payment will be made for the dismantled concrete, the relevant formwork and reinforcement, embedded mixtures etc. wasted in the dismantled portion shall be made. In the course of dismantling if any damage is done to the embedded items or adjacent structures, the same shall also be made good free of charge by the contractor to the satisfaction of the Engineer in charge. If the water quantity has to be increased in special cases, cement also be increased proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete.

4.9.2.3 WORKABILITY

The workability of concrete shall be checked at frequent intervals by slump test. Where facilities exist and if required by the Engineer-in-Charge, alternatively the compacting factor test in accordance with IS: 1199 shall be carried out. The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of form work and round the reinforcement to give the required surface finish shall depend on the type and nature of the structure and shall be based on experience and tests. The limits of consistency for structures are as specified in the table below:

Table 8 : Limits of Consistency

Placing Conditions	Degree of Workability	Values of Workability
Concreting of shallow Sections with vibration	Very low	20-10 seconds Veebee time or 0.75-0.80 compacting factor
Concreting of lightly Reinforced sections With vibration	Low	10-5 seconds or 0.80-0.85 compacting factor
Concreting of lightly Reinforced sections Without Vibration or Heavily reinforced Section with Vibration	Medium	5-2 seconds Veebee time or 0.85-0.92 compacting factor or 25-75mm slump for 20 mm Aggregate
Concreting of heavily Reinforced sections compacting Without vibration factor	High	Above 0.92 compacting factor or 75-125 mm slumps for 20 mm aggregate

4.9.3 Workmanship

All workmanship shall be according to the latest relevant standards. Before starting a pour the contractor shall obtain the approval of the Engineer-in-Charge in a "Pour Card" maintained for this purpose. He shall obtain complete instructions about the material and proportion to be used, slump, workability of water per unit of cement, number of test cubes to be taken, finishing to be done and any admixture to be added etc.

4.10 SAMPLING AND TESTING CONCRETE IN THE FIELD

Sampling and Testing of Concrete shall conform to IS: 456 2000.

- a) Facilities required for sampling materials and concrete including whether proof buildings to house the facilities in the field, shall be provided by the contractor at no extra cost. The following equipment with operator shall be made available in serviceable conditions.
 - i. Concrete cube-testing machine suitable for 15 cm cubes of 100 tonnes capacity with proving calibration ring 1 no.
 - ii. Cast iron cube moulds 15 cm size 30 nos.
 - iii. Slump cone complete with tamping rod 5 sets
 - iv. Laboratory balance to weigh up to 5 kg with sensitivity of 10 gm 1 no.
 - v. BIS sieves for coarse and fine aggregates 1 set
 - vi. Set of measures from 5 litres to 0.1 litre 1 set
 - vii. Electric oven with thermostat up to 120° C 1 no.
 - viii. Flakiness gauge 1 no.
 - ix. Elongation index gauge 1 no.
 - x. Sedimentation pipette 1 no.
 - xi. Calibrated glass jar 1.0 litre capacity 2 nos.

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|-------|--|--------------|
| xii. | Glass flasks and metal containers | As required |
| xiii. | Chemical reagents like sodium hydroxide,
Tannic acid, litmus paper etc. - | As required |
| xiv. | Laboratory balance of 2 kg capacity and
sensitivity of 1 gm - | 1 no. |
| xv. | Weighing Machine for cement bags of 6 Nos.: | 2 no. |
| xvi. | Vernier Calipers | As required. |
| xvii. | Thermometer for concrete | |
- b) No concrete of any kind may be placed until the field concrete testing laboratory as specified is provided to the satisfaction of the Engineer-in charge. The contractor shall notify the Engineer-in charge in advance of all concrete and concrete material testing as provided in the clause to provide the Engineer/his representative with an opportunity to witness all prescribed tests.
- c) At least 6 test cubes of each class of concrete shall be made of every 50cum concrete or part thereof or from different batches as directed by Engineer-in-Charge. Such samples shall be drawn on each day for each type of concrete. Of each set of 6 cubes, three shall be tested at 7 days age and three at 28 days age. The cubes must be cast from various batches to arrive at an average strength. The laboratory test results shall be tabulated and furnished to the Engineer. The Engineer will pass the concrete if average strength of the specimens tested is not less than the strength specified, subject to the condition that only one out of three consecutive tests may give a value less than the specified strength but this shall not be less than 90% of the specified strength.
- d) Consistency: Slump tests shall be carried out as often as requested by the Engineer and invariably from the same batch of concrete from which the test cubes are made. Slump tests shall be done immediately after sampling.

4.11 Concrete Tests

The Engineer-in-Charge, may order tests to be carried out on cement, sand, coarse aggregate, water in accordance with the relevant Indian standards.

Tests on Cement shall include:

- Fineness test
- Test for normal consistency
- Test for setting time
- Test for soundness
- Test for tensile strength
- Test for compressive strength
- Test for heat of hydration (by experiment and by calculations) in accordance with BIS 269

Tests on Sand shall include:

- Sieve test
- Test for organic impurities
- Decantation test for determining clay and silt content
- Specific gravity test
- Test for unit weight and bulkage factor

- Test for sieve analysis and fineness modulus

Tests on Coarse Aggregate shall include:

- Sieve analysis
- Specific gravity and unit weight of dry, loose and rodded aggregate
- Soundness and alkali aggregate reactivity
- Petrography examination
- Deleterious materials and organic impurities
- Test for aggregate crushing value

Any or all these tests would normally be ordered to be carried out only if the Engineer feels the materials are not obtained and shall be performed by the contractor at an approved test laboratory or at MCGM laboratory. The contractor shall bear the charges of these optional tests.

Concrete not made to the requirements of specification in all respects may be rejected by the Engineer-in-Charge in which case it shall be removed and reconstructed entirely at the expense of the contractor.

4.11.1 Load test on Members or any other tests

- i) In the event of any work being suspected of material or workmanship or both, the Engineer-in-Charge requiring its removal and reconstruction may order, or the contractor may request that it should be load tested in accordance with the following provisions.
- ii) The test load shall be 125% of the maximum superimposed load for which the structure was designed. Such test load shall not be applied before 56 days after the effective hardening of concrete. During the test, struts strong enough to take the whole load shall be placed in position leaving a gap under the members. The test load shall be maintained for 24 hours before removal.
- iii) If within 24 hours of the removal of the load, the structure does not show a recovery of at least 75% of the maximum deflection shown during the 24 hours under load, the test loading shall be repeated after a lapse of at least 72 hours. The structure shall be considered to have failed to pass the test if the recovery after the second test is not at least 75% of the maximum deflection shown during the second test. If the structure is certified as failed by the Engineer-in-Charge, the cost of all the new construction and the load tests shall be borne by the contractor.
- iv) Any other tests, e.g. taking out in an approved manner concrete cores, examination and tests on such cores removed from such parts of the structure as directed by the Engineer-in-Charge, sonic testing etc. shall be carried out by the contractor, if so directed, at no extra cost.

4.11.2 Unsatisfactory tests

Should the results of any test prove unsatisfactory, or the structure shows signs of weakness, undue deflection or faulty construction, the contractor shall remove and rebuild the member or members involved or carry out such other remedial measures as may be required by the Engineer-in-Charge.

4.12 Admixtures

4.12.1 General

Admixtures may be used in concrete where required, only with the approval of the Engineer-in-Charge. However it should be seen that, with the passage of time, neither the compressive strength nor its durability is reduced. 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 to be used, such as in mass concrete works, it shall be dissolved in water and added to the mixing water in an amount not exceeding 1.5% of the weight of the cement in each batch of concrete. When admixtures are used, the designed concrete mix shall be corrected accordingly. Admixtures shall be used as per manufacturer's instruction and in the manner and with the control specified by the Engineer-in-Charge.

4.12.2 Air Entraining Agents

Neutralized vinsol resin or other approved air in the concrete mix agents shall conform to the requirements of ASTM standard 6.260; Air Entraining Admixtures for Concrete. The recommended total air content of the concrete is $4\% \pm 1\%$. The method of measuring air content shall be as per IS: 1199.

4.12.3 Water Reducing Admixtures

Water reducing lignosulfonate admixture may be added in quantities approved by the Engineer-in-Charge. The admixtures shall be added in the form of a solution.

4.12.4 Retarding Admixtures

Retarding agents may be added to the concrete mix in quantities approved by the Engineer-in-Charge.

4.12.5 Water Proofing Agent

Water proofing agents shall conform to IS:2645.

4.12.6 Other Admixtures

The Engineer-in-Charge may at his discretion allow the contractor to use any other admixture in the concrete.

4.13 Preparation Prior to Concrete Placement, Final Inspection and Approval

- a. Before the concrete is actually placed in position, the insides of the formwork shall be inspected to see that they have been cleaned and oiled. Temporary openings shall be provided to facilitate inspection, especially at bottoms of columns and wall forms, to permit removal of sawdust, wood shavings, binding wire, dirt etc. Openings shall be placed or holes drilled so that these materials and water can be removed easily. Such openings/holes shall be suitably plugged later.
- b. The various agencies shall be permitted ample time to install drainage and plumbing lines, floor and trench drains, conduits, hangers, anchors, inserts, sleeves, bolts, frames and other miscellaneous embedment to be cast in the

concrete as specified or required or as is necessary for the proper execution of the work as specified in the drawings.

- c. All embedded parts, inserts, etc. supplied by the MCGM or the contractor shall be correctly positioned and securely held in the forms to prevent displacement during depositing and vibrating of concrete.
- d. All anchor bolts shall be positioned and kept in place with the help of properly manufactured templates unless specifically waived in writing by the Engineer-in-Charge.
- e. Slots, openings, holes, pockets etc. shall be provided in the concrete work in the position specified in drawing or required or as directed by the Engineer-in-Charge.
- f. Reinforcement and other items to be cast in concrete shall have clean surfaces that will not impair bond.
- g. Prior to concrete placement, all work shall be inspected and approved by the Engineer-in-Charge and if found unsatisfactory, concrete shall not be poured until after all defects have been corrected.
- h. Approval by the Engineer-in-Charge of any and all materials and work as required herein shall not relieve the contractor from his obligation to produce finished concrete in accordance with the requirements of the specifications.
- i. Rain or wash water
No concrete shall be placed in wet weather or on a water-covered surface. Any concrete that has been washed by heavy rains shall be entirely removed, if there is any sign of cement and sand having been washed away from the concrete mixture. To guard against damage, which may be caused by rains, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work unattended. Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no further concrete shall be placed thereon until such water is removed. To avoid flow of water over/around freshly placed concrete, suitable drains and sumps shall be provided. During summer season, temperature of water should be maintained, as per the criteria and for the same, icing should be done for concreting work.
- j. Bonding Mortar
Immediately before concrete placement begins, prepared surfaces except formwork, which will come in contact with the concrete to be placed, shall be covered with a bonding mortar as specified.
- k. The corrosive on the reinforcement should be removed by means of wire brush.
- l. Laitance should be removed by means of chiseling from top concrete layer, which was earlier concreted

4.14 Transportation

4.14.1 General

All buckets, containers or conveyors used for transporting concrete shall be mortar-tight, leak proof irrespective of the method of transportation adopted, concrete shall be delivered with the required consistency and plasticity without segregation or loss of slump. However, chutes shall not be used for transport of concrete without the written permission of the Engineer-in-Charge and concrete shall not be re-handled before placing.

4.14.2 Re-tempered or Contaminated Concrete

Concrete must be placed in its final position before it becomes too stiff to work. On no account, water shall be added after the initial mixing. Concrete, which has become stiff or has been contaminated with foreign materials shall be rejected and disposed off as directed by the Engineer-in-Charge.

4.14.3 Avoiding Segregation

Concrete shall, in all cases, be deposited as nearly as practicable directly, in its final position and shall not be re-handled to flow in a manner which will cause segregation, loss of materials, displacement of reinforcement, shuttering or embedded insets, or impair its strength. For locations where direct placement is not possible, and in narrow forms, the Contractor shall provide suitable drop and "Elephant Trunks" to confine the movement of concrete. Special care shall be taken when concrete is dropped from a height, especially if reinforcement is in the way, particularly in column and the walls.

4.14.4 Placing by Manual Labour

Except when otherwise approved by the Engineer-in-Charge, concrete shall be placed in the shuttering by shovels or other approved implements, and shall not be dropped from a height more than 1.0 m or handled in a manner, which will cause segregation.

4.14.5 Placing by Mechanical Equipment

The following specification shall apply when placing concrete by use of mechanical equipment is warranted considering the nature of work involved. The control of placing shall begin at the mixer discharge. Concrete shall be discharged by a vertical drop into the middle of the bucket or hopper and this principle of a vertical discharge of concrete shall be adhered to throughout all stages of delivery until the concrete comes to rest in its final position.

4.14.5.1 Types of Buckets

Central-bottom-dump buckets of a type that provides for positive regulation of the amount and rate of deposition of concrete in all dumping positions, shall be employed.

4.14.5.2 Operation of Bucket

In placing concrete in large open areas, the bucket shall be spotted directly over the position designated and then lowered for dumping. The open bucket shall clear the concrete already in place and the height of drop shall not exceed 1.0 m. The bucket

shall be opened slowly to avoid high vertical bounce. Dumping of buckets on the swing or in any manner, which results in separation of ingredients or disturbance of previously placed concrete, will not be permitted.

4.14.6 Placement of Restricted Forms

Concrete placed in restricted forms by barrows, buggies, cars, short chutes or hand shoveling shall be subject to the requirement for vertical delivery of limited height to avoid segregation and shall be deposited as nearly as practicable in its final position.

4.14.7 Chuting

Where it is necessary to use transfer chutes, specific approval of Engineer-in-Charge must be obtained to type, length slopes, baffles, vertical terminals and timing of operations. These shall be so arranged that an almost continuous flow of concrete be obtained at the discharge and without segregation. Concrete should flow smoothly in the chute and there should not be any obstruction to the flow. To allow for the loss of mortar against the sides of the chutes, the first mixes shall have less coarse aggregate. During cleaning of chutes, the wastewater shall be kept clear of the forms. Concrete shall not be permitted to fall from the end of the chutes by more than 1.0 m. Chutes, when approved for use shall have slopes not flatter than 1 vertical, 3 horizontal and not steeper than 1 vertical, 2 horizontal. Chutes shall be of metal or metal lined end of rounded cross section. The slopes of all chute sections shall be approximately the same. The slopes of all chute sections shall be approximately the same. The discharge end of the chutes shall be maintained above the surface of the concrete in the forms.

4.14.8 Placing by Pumping/Pneumatic Placers

Concrete may be conveyed and placed by mechanically operated equipment e.g., pumps or pneumatic placers only with the written permission of the Engineer-in-Charge at no extra cost. The slump shall be held to the minimum necessary for conveying concrete by this method.

When pumping is adopted, before pumping of concrete is started, the pipeline shall be lubricated with one or two batches of mortar composed of one part cement and two parts sand. Care shall be taken to avoid stoppages in work once pumping has started.

When a pneumatic placer is used, the manufacturer's advice on layout of the pipeline shall be followed to avoid blockages and excessive wear. Restraint shall be provided at the discharge box to cater for the reaction at this end. Manufacturer's recommendations shall be followed regarding concrete quality and all other related matters when pumping/pneumatic placing equipment is used. It should be noted that no extra payment is made for these items, if required and directed by Engineer-in-Charge.

4.14.9 Concrete in Layers

Concreting, once started, shall be continuous until the pour is completed. Concrete shall be placed in successive horizontal layers of uniform thickness ranging from 15 cm to 45 cm directed by Engineer-in-Charge. These shall be placed as rapidly practicable to prevent the formation of cold joints or planes of weakness between each succeeding layer within the pour. The thickness of each layer shall be such that it can be deposited before the previous layer has stiffened. The bucket loads or other units of deposit, shall be spotted progressively along the face of the layer with such overlap as will facilitate spreading the layer to uniform depth and texture with a minimum shoveling. Any

tendency to segregation shall be corrected by shoveling stones into mortar rather than mortar on to stones. Such a condition shall be corrected by redesign of mix or other means, as directed by the Engineer-in-Charge.

4.14.10 Cover Blocks

Cover blocks of required size depending on the cover of the reinforcement as mentioned in the drawings shall be prepared in 1:3 cement mortar with fine aggregates.

4.14.11 Bedding of Layers

The top surface of each pour and bedding planes shall be approximately horizontal unless otherwise instructed. Top layer should be rough and with key for further extension of work.

4.14.12 Compaction

Concrete shall be compacted during placing with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, as specified in the IS, is free of pockets of coarse aggregate and fits tightly against all form surfaces, reinforcement and embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into corners of forms against hardened concrete at joints is free from voids or cavities. The use of vibrators shall be consistent with the concrete mix and caution exercised not to over vibrate the concrete to the point that segregation results.

4.14.12.1 Type of Vibrators

Vibrators shall conform to BIS specifications. Type of vibrator to be used shall depend on the structures where concrete is to be placed. Shutter vibrators to be effective, shall be firmly secured to the formwork which must be sufficiently rigid to transmit the vibration and strong enough not to be damaged by it. Immersion vibrators in sufficient numbers and each of adequate size shall be used to properly consolidate all concrete. Tapping or external vibrating of forms by hand tools or immersion vibrators will not be permitted.

4.14.12.2 Use of Vibrators

The exact manner of application and the most suitable machines for the purpose must be carefully considered and operated by experienced men. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn when air bubbles cease to come to the surface. Immersion vibrators shall be withdrawn very slowly. In no case shall immersion vibrators be used to transport concrete inside the forms. Particular attention be paid to vibration at the top of a lift e.g. in a column or wall.

4.14.12.3 Melding Successive Batches

When placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration blending and melding of the concrete between the succeeding layers.

4.14.12.4 Penetration of Vibrators

The immersion vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

4.14.12.5 Vibrating against Reinforcement

Care shall be taken to prevent contact of immersion vibrators against reinforcement steel. Immersion vibrators shall not be allowed to come in contact with reinforcement steel after start of initial set. They shall also not be allowed to come in contact with forms or finished surfaces.

4.14.12.6 Use of Form Attached Vibrators

Form attached vibrators shall be used only with specific authorization of the Engineer-in-Charge.

4.14.12.7 Use of surface Vibrators

The use of surface vibrators will not be permitted under normal conditions. However, for thin slabs, surface vibrating by specially designed vibrators may be permitted, upon approval of Engineer-in-Charge.

4.14.12.8 Stone Pockets and Mortar Pondages

The formation of stone pockets and mortar pondages in corners and against faces of forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for thorough bonding, as directed by the Engineer-in-Charge.

4.14.13 Placement Interval

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 and before the start of a subsequent placement.

4.14.14 Special Provision in Placing

When placing concrete in walls with openings, in floors of integral slabs and beam construction and other similar conditions, the placing shall stop when the concrete reaches the top of the opening in walls or bottom horizontal surface of the slab, as the case may be.

Placing shall be resumed before the concrete in place takes initial set, but not until it has had time to settle as determined by the Engineer-in-Charge.

4.14.15 Placing Concrete through Reinforcing Steel

When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregate. Where the congestion of steel makes placing difficult, it may be necessary to obtain Engineer in-Charge's permission for temporarily

moving the top steel aside for proper placement & for restoring reinforcement as per drawing.

4.14.16 Bleeding

If bleeding or free water on top of concrete being deposited into the forms is observed, the concrete pour shall be stopped and the conditions causing this defect corrected before any further concreting is resumed.

4.14.17 Ready Mix Concrete (RMC)

All Ready Mix Concrete shall conform to IS 4926-2003.

Ready-mixed concrete shall be transported from the mixer to the point of placing as rapidly as practicable by methods that will maintain the required workability and will prevent segregation, loss of any constituents or ingress of foreign matter or water. The concrete shall be placed as soon as possible after delivery, as close as is practicable to its final position to avoid rehandling or moving the concrete horizontally by vibration. If required by the contractor he can utilize admixtures to slow down the rate of workability loss, however this does not remove the need for the contractor to place the concrete as rapidly as possible. The contractor should plan his arrangements so as to enable a full load of concrete to be discharged within 30 min of arrival on site.

Concrete shall be transported in a transit-mixer.

4.14.17.1 Time in Transport

The general requirement is that concrete shall be discharged from the transit-mixer within 2 hours of the time of loading. However, a longer period may be permitted if retarding admixtures are used or in cool humid weather.

The time of loading shall start from adding the mixing water to the dry mix of cement and aggregate or of adding the cement to the wet aggregate whichever is applicable.

Ready-mixed concrete plant shall have test facilities at its premises to carry out routine tests as per the requirement of the standard.

4.14.17.2 Workability

The test for acceptance is to be performed upon the contractors delivery vehicle discharge on site. If discharge from the contractors vehicle is delayed on site for more than 30 min., the workability shall be evaluated and shall be within the following limits on the specified value:

Slump Compacting factor: + 25 mm or + 1/3 of the specified value, whichever is less.

+ 0.03, where the specified value is 0.90 or greater,

* 0.04, where the specified value is less than 0.90 but more than 0.80, and + 0.05, where the specified value is 0.80 or less.

Flow table test may be specified for concrete, for very high workability (see IS 9103).

4.15 Application of Mineral Based Bonding Agent for Bonding of New and Old Concrete

4.15.1 General

Mineral based bonding agent will be used to bond fresh concrete to concrete that is fully cured, to give a monolithic bond capable of transmitting high stresses when traditional bonding agents such as cement slurry cannot always be relied upon to provide good adhesion which is particularly the case when large areas are involved.

The Mineral based formulation shall be applied to a suitably prepared concrete substrata and the fresh concrete poured as soon as possible, but always during the 'open time' of the adhesive.

Materials used shall be of best quality and approved by the Engineer-in-Charge.

Manufacturer's instructions shall be followed in all respects.

No separate payment shall be paid for this item of work.

4.15.2 Formulation

Bonding agent	100	Pbw	
Water	19	Pbw	

4.15.3 Application

4.15.3.1 Preparation of the Substrata

To obtain good adhesion, it is necessary to have clean and sound substrata. Preparation can be carried out using a variety of techniques including chemical treatment and mechanical methods such as grinding, milling, abrading, planning and sand blasting. Dust and loose particles resulting from the pretreatment should be removed by vacuum cleaning.

4.15.3.2 Mixing

The powder and water shall be thoroughly mixed by using slow speed stirrer. The mixed, ready to use adhesive should not contain lumps of unwetted filler and should be of uniform color.

4.15.3.3 Pot life and 'Open time'

The pot life is the period during which the ready to use Mineral based formulation must be applied. After this period, the mix can no longer be worked and will have begun to set in its container. The table below indicates the pot life at different temperatures:

Mix Temperature	Pot life in minutes
5° C	75 Minutes

20° C	60 Minutes
30° C	45 Minutes

(The figures in this table are for batches less than 1 kilogram).

The 'Open time' is the maximum period of time allowable between application of the Mineral Based adhesive and pouring the fresh concrete. Exceeding the 'Open time' would result in considerably reduced adhesion. The adhesive should be applied to the pre-treated substrata as soon as the components have been mixed and fresh concrete poured immediately afterwards.

Accurate knowledge of the 'Open time' is essential in case the work is interrupted. Table gives the 'Open time' of Mineral Based formulations as a function of substrata temperature. In all cases, the adhesives shall be applied immediately after mixing. Any delay between mixing and application will reduce the 'Open time'. Fresh concrete must be poured before the adhesive begins to gel. New to old concrete bonding is not recommended at temperatures below 5 Degree Centigrade as curing cannot be assured under these circumstances.

4.15.3.4 Methods of Application

The shape and size of the concrete structure will determine the method of application used. The Mineral Based adhesive may be applied by hand using brush, brooms or any other suitable applicator.

4.15.3.5 Suitability of Fresh Concrete

Best results are obtained when the water/ cement ratio of the new concrete is low as is practicable.

4.15.3.6 Coverage

One kilogram of the mixed Mineral Based adhesive including Powder and Water covers an area of 1 to 1.1 sq.m. When applied with a stiff nylon bristle brush. However, the coverage is very much dependent on the finish of the concrete.

4.16 Handling Precautions

Mineral Based Bonding Agents can cause irritation of the skin in sensitive persons if incorrectly handled. Certain safety precautions must therefore be observed and those handling the powder should be given suitable instructions. Those working with powder should, above all, be instructed that personal cleanliness at the place of work is essential. The powder should not be allowed to come into direct contact with the skin. The most effective protection is achieved by wearing rubber or polythene gloves, the latter having the advantage that they can be replaced when dirty. They are more pleasant to wear if cotton gloves are worn underneath. Parts of the skins, which have come into contact with the resin or hardener, should be washed with lukewarm water and a mild soap. Special cleaning creams may be used as they have proved to be highly suitable.

4.17 Construction Joints

A construction joint is defined as a joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement.

No concreting shall be started until the Engineer-in-Charge has approved the method of placing the positions and form of the construction joints and lifts. The construction joints shall be so located as not to impair the strength of the structure. Water stops shall be inserted as per clause 3.20

Concrete placed to form the face of a construction joint shall have all Laitance removed and the aggregate exposed prior to the placing of fresh concrete. The Laitance shall wherever practicable be removed by spraying the concrete where it is still green. The whole of the concrete surface forming part of the joint shall be hacked to expose the aggregate. Where aggregate is damaged during hacking, it shall be removed from the concrete face by further hacking. All loose matter shall be removed and the exposed surface thoroughly cleaned by wire brushing, air blasting or washing, leaving the surface clean and damp. Immediately before fresh concrete is placed, a 12 mm thick layer of sand/cement mortar mixed in the same proportions as in the concrete shall be spread in the horizontal face of the construction joint. A drier mix shall be used for the top lift of horizontal face of the construction joint. A drier mix shall be used for the top lift of horizontal pours to avoid Laitance. The new concrete shall be well worked against the prepared face before the mortar sets. Special care shall be taken to obtain thorough compaction and to avoid segregation of the concrete along the joint plane.

4.18 Movement Joints

Movement joints are defined as all joints intended to accommodate relative movement between adjoining parts of a structure, special provision being made where necessary for maintaining the water tightness of the joint. The contractor shall comply with the instructions of manufacturers of proprietary jointing materials and shall, if required by the Engineer-in-Charge, demonstrate that the jointing materials can be applied satisfactorily.

The surface of set concrete in a movement joint shall, as shown on the drawings, be painted with two coats of MC-DUR 1700 or approved equivalent and new concrete shall be placed against it only when the paint is dry. Expansion joints shall be formed by a separating strip of approved preformed joint filler.

Caulking grooves shall be provided. At all joints where a caulking groove is formed, immediately prior to caulking, the groove shall be wire brushed and loose material removed and blown out by compressed air. After the groove has dried, it shall be primed and caulked with approved sealing compound applied in accordance with the manufacturer's instructions by MC Injection Series or approved equivalent. At all caulked joints, the face of the caulking strip and a width of concrete on either side shall be painted with two coats of paint having the same base as the sealing compound. The detailed methodology should be submitted and got approved from Engineer-in-Charge prior to execution of work.

4.19 Water Stops and Joint Fillers

4.19.1 Water stops

Water stops shall be provided at all construction, contraction and expansion joints in the water retaining structures and wherever specified or directed by the Engineer-in-Charge. The water stops shall be PVC type or of any other equivalent material as approved by the Engineer-in-Charge. PVC water stops shall have a tensile strength of not less than 14 MN/m² and elongation at break of not less than 300%. Water stops shall not be exposed to direct sunlight for long periods. Before being concreted in water stops shall be cleaned of all foreign materials. Wherever provided, water stops shall be placed in such a manner that they are embedded in the adjacent sections of the panels for equal width.

As far as possible, jointing on site shall be confined to the making of butt joints in straight runs of water stops and all the joints should be monolithic. Where it is agreed with the Engineer-in-Charge that it is necessary to make an intersection or change of direction of any joint, other than a butt joint in a straight run on site, a preliminary joint, intersection or change of direction piece shall be made and submitted to such tests as the Engineer-in-Charge may require.

Flexible water stops shall be fully supported in the formwork, free of nails and clear of reinforcement and other fixtures. Damaged water stops shall be replaced and during concreting care shall be taken to place the concrete so that water stops do not bend or distort.

The different types of water stops to be used in liquid retaining structures will be as follows:

Table 9 : Types of Water Stops

Sr.	Type of Joint	Type of water stops
1.	Partial/complete contraction joint in walls and slabs	230 mm wide, ribbed with hollow centre bulb & 6 mm minimum thickness
2.	Expansion joints in walls and slabs	230 mm wide, ribbed with hollow centre bulb & 6 mm minimum thickness
3.	Construction joint in raft	230 mm wide, ribbed with hollow centre bulb & 6 mm minimum thickness
4.	Construction joint in wall	230 mm wide, ribbed with hollow centre bulb & 6 mm minimum thickness
5.	Expansion joint raft	230 mm wide, ribbed with hollow centre bulb & 6 mm minimum thickness

4.19.2 Jointing fillers

Joint fillers shall be of durable, compressible and non-extruding material.

4.20 Sealing Compounds

Horizontal joints shall, when used in water-retaining structures be sealed with MC Injection Series or approved equivalent. The detailed methodology should be submitted and got approved from Engineer-in-Charge prior to execution of work. Tolerances in Concrete Surfaces.

Concrete surfaces for the various classes of unformed and formed finishes specified in various clauses shall comply with the tolerances shown in Table hereunder, except where different tolerances are expressly required by the specification.

In the table 'line and level' and 'dimension' shall mean the lines, levels and cross-sectional dimensions as specified and required.

- Surface irregularities shall be classified as 'abrupt' or 'gradual'. Abrupt irregularities shall include but not be limited to offsets and fins caused by displaced or misplaced formwork, loose knots and other defects in formwork materials, and shall be tested by direct measurement. Gradual irregularities shall be tested by means of a straight template for plane surfaces and 1.5 m long formed surfaces.

Class of finish	Maximum tolerance (mm) in:			
	Line & level	Abrupt irregularity	Gradual irregularity	Dimension
U 1	12	6	6	-
U 2	6	3	3	-
U 3	6	3	3	-
F 1	12	6	6	+12-6
F 2	6	6	6	+12-6
F 3	3	3	3	+6-

4.21 Curing, Protecting, Repairing and Finishing

4.21.1 Curing

All concrete shall be cured by keeping it continuously damp for the period of time required for complete hydration and hardening to take place. Preference shall be given to the use of continuous sprays, or ponding of water, continuously saturated coverings of sacking, canvas, Hessian or other absorbent materials, or approved effective curing compounds applied with spraying equipment capable of producing a smooth, even textured coat. Extra precautions shall be exercised in curing concrete during cold and hot weather as outlined hereinafter. The quality of curing water shall be the same as that used for mixing concrete.

4.21.2 Curing with Water

Fresh concrete shall be kept continuously wet for a minimum period of 10 days from the date of placing of concrete, following a lapse of 12 to 14 hours after laying of concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin as soon as the concrete has hardened. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled so as to prevent erosion of freshly placed concrete.

4.21.3 Continuous Spraying

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances of hose, sprinklers and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by the Engineer-in-Charge.

4.21.4 Alternate Curing Methods

Whenever in the judgment of the Engineer-in-Charge, it is necessary to omit the continuous spray method, a covering of clean sand or other approved means such as wet gunny bags, which will prevent loss of moisture from the concrete, may be used. No type of covering will be approved which would stain or damage the concrete during or after the curing period. Covering shall be kept continuously wet during curing period. For curing of concrete in sidewalks, floors, flat roofs of other level surfaces, the ponding method of curing is preferred. The method of containing the ponded water shall be approved by the Engineer-in-Charge. Special attention shall be given to edges and corners of the slabs to ensure proper protection to these areas. The ponded areas shall be kept continuously filled with water during the curing period.

4.21.5 Curing Compound

Surface coating type-curing compounds shall be used only by special permission of Engineer-in-Charge. Curing compounds shall be liquid type white pigmented, conforming to US Bureau of Reclamation specification. No curing compound shall be used on surfaces where future blending with concrete, water or acid proof membrane or painting is specified.

4.21.6 Curing Equipment

All equipment and materials required for curing shall be on hand and ready for use before concrete is placed.

4.21.7 Protecting Fresh Concrete

Fresh concrete shall be protected from defacements and damage due to construction operations by leaving forms in place for an ample period as specified in section D3 of this specification. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by the Engineer-in-Charge shall also be taken to protect immature concrete from damage by debris, excessive lading, vibration, abrasion or contact with other materials, etc. that may impair the strength and/or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that the workmen enter the area of freshly placed concrete, the Engineer-in-Charge may require that bridges be placed over the area.

4.21.8 Repair and Replacement of Unsatisfactory Concrete

4.21.8.1 General

Immediately after the shuttering is removed, the surface of concrete shall be very carefully gone over and all defective areas called to the attention of the Engineer-in-Charge who may permit patching of the defective areas or also reject the concrete unit either partially or in its entirety. Rejected concrete shall be removed and replaced by the contractor. Holes shall be filled with High Strength Non-shrink Grout approved by MCGM. Superficial honey combed surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of the Engineer-in-Charge and superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float. Excess water shall be avoided. Unless instructed otherwise by the Engineer-in-Charge, the surface of the exposed concrete placed against shuttering shall be rubbed down immediately on removal of shuttering to remove fine or other irregularities, care being taken to avoid damaging the surface. Surface irregularities shall be removed by grinding. If reinforcement is exposed or the honeycombing occurs at vulnerable positions e.g. ends of beams or columns, it may be necessary to cut out the member completely or in part and reconstruct. The decision of the Engineer-in-Charge shall be final in this regard. If only patching is necessary, the edges being cut perpendicular to the affected surface or with a small undercut if possible. Anchors, tees or dovetail slots shall be provided whenever necessary to attach the new concrete securely in place. An area extending several centimeters beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.

4.21.8.2 Use of Epoxy / Polymer

The use of epoxy / polymer for bonding fresh concrete used for repairs will be permitted upon written approval of the Engineer-in-Charge. Epoxies shall be applied in strict accordance with the instructions of the manufacturer.

4.21.8.3 Method of Repair

Small size holes having surface dimensions about equal to the depth of the hole, holes left after removal of form bolts, grout insert holes and slots cut for repair of cracks shall be repaired as follows.

The hole to be patched shall be roughened and thoroughly soaked with clean water until absorption stops. A 5 mm thick layer of grout of high strength non-shrink grout approved by MCGM shall be well brushed into the surface to be patched, followed immediately by the patching concrete which shall be well consolidated with a wooden float and left slightly protruding from the surrounding surface. The concrete patch shall be built up in 10 mm thick layers, after an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden float and a smooth finish obtained by wiping with hessian cloth. A steel trowel shall be used for this purpose. The mix for patching shall be of the same materials and in the same proportion as that used in the concrete being repaired, although some reduction in the maximum size of the coarse aggregates may be necessary and the mix shall be kept as dry as possible. Hydraulically setting polymer mortar approved by MCGM shall be used to patch up the surface by using appropriate

approved bonding agent. Patched surfaces shall be given a final treatment to match the colour and texture of the surrounding concrete. White cement shall be substituted for ordinary cement, if so directed by the Engineer-in-Charge, to match the shade of the patch with the original concrete.

4.21.8.4 Curing of Patched Work

The patched area shall be covered immediately with an approved non-staining, water-saturated material such as gunny bags, which shall be kept continuously wet and protected against sun and wind for a period of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray, or sprinkling for not less than 10 days. All fillings shall be tightly bounded to the concrete and shall be sound, free from shrinkage cracks after the fillings have been cured and dried.

4.21.8.5 Approval by the Engineer-in-Charge

All materials, procedures and operations used in the repair work shall be subject to the approval of the Engineer-in-Charge.

4.21.9 Finishing

4.21.9.1 General

The type of finish for formed concrete surfaces shall be as follows, unless varied by the Engineer-in-Charge.

When the structure is in service all the surfaces shall receive no special finish, except repair of damaged or defective concrete, removal of fine and abrupt irregularities, filling defective concrete, filling of holes left by form ties and rods and cleanup of loose or adhering debris. Surfaces which will be exposed to the weather and which would normally be level shall be sloped for drainage. Unless a horizontal surface or the slope required is specified, the tops of narrow surfaces such as stair treads, walls, curbs and parapets shall be sloped across the width approximately 1 in 30. Broader surfaces such as walkways and platforms shall be sloped about 1 in 50. Surfaces that will be covered by backfill or concrete, sub floors to be covered with concrete topping, terrazzo or quarry tiles and similar surfaces shall be smooth ascended and leveled to produce even surfaces. Surface irregularities shall not exceed 6 mm. Surfaces which will not be covered by backfill, concrete or tile toppings such as outside decks, floors of galleries and sumps, parapets, gutters, side-walks, floors and slabs, shall be consolidated, screened and floated. Excess water and laitance shall be removed before final finishing. Floating may be done with hand or power tools and started as soon as the screened surface has attained a stiffness to permit finishing operations and these shall be the minimum required to produce a surface uniform in texture and free from screened marks or other imperfections. Joints and edges shall be tooled as specified or as directed by the Engineer-in-Charge.

4.21.9.2 Standard Finish for Exposed Concrete

Exposed concrete shall mean any concrete, other than floors or slabs, exposed to view upon completion of the works. Unless otherwise specified, the standard finish for exposed concrete shall be a smooth finish. A smooth finish shall be obtained with the use of lined or plywood forms having smooth and even surfaces and edges. Panels of forms shall be of uniform size and be as large as practicable and installed with closed joints. Upon removal of forms the joint marks shall be smoothed off and all blemishes, protections etc., removed leaving the surfaces smooth. Integral Cement Concrete Finish When specified, integral cement concrete finish of specified thickness for floors and slabs shall be applied either monolithic or bonded, as specified or directed by the Engineer-in-Charge. The surface shall be tested with a straight edge and any high and low spots eliminated. Floating or toweling of the finish shall be permitted only after all surface water has evaporated. Dry cement or a mixture of dry cement and sand shall not be sprinkled directly on the surface of the cement finish to absorb moisture or to stiffen the mix.

4.21.9.3 Rubbed finish

A rubbed finish shall be provided only on exposed concrete surfaces. Upon removal of forms, all fins and other projections on the surfaces shall be carefully removed, offsets leveled and voids and/or damaged sections immediately saturated with water and repaired by filling with a concrete or mortar of the same composition as was used in the surface. The surfaces shall then be thoroughly wetted and rubbed with carborundum or other abrasive. Cement mortar may be used in the rubbing, but the finished surfaces shall not be brush coated with either cement or grout after rubbing. The finished surfaces shall present a uniform and smooth appearance.

4.21.9.4 Protection

All concrete shall be protected against damage until final acceptance by the Engineer-in-Charge.

4.22 Hot Weather Requirement

All Concrete work performed in hot weather shall be in accordance with IS: 456, except as herein modified.

Admixtures may be used only when approved by the Engineer-in-Charge.

Adequate provisions shall be made to lower concrete temperatures by cool ingredients, eliminating excessive mixing, preventing exposure of mixers and conveyors to direct sunlight and the use of reflective paint on mixers etc. The temperature of the freshly placed concrete shall not be permitted to exceed 38 degrees centigrade.

Consideration shall be given to shading aggregate stockpiles from direct rays of the sun and spraying stockpiles with water, use of cold water when available, and burying, insulating, shading and/or painting white the pipelines and water storage tanks and conveyance.

In order to reduce loss of mixing water, the aggregate, wooden forms, subgrade, adjacent concrete and other moisture absorbing surfaces shall be well wetted prior to concreting, placement and finishing shall be done as quickly as possible.

Extra precautions shall be taken for the protection and curing of concrete. Consideration shall be given to continuous curing and protection against high temperatures and drying hot winds for a period of at least 7 days immediately after concrete has set and after which normal curing procedures may be resumed.

4.23 Placing Concrete Underwater

- a) Under all ordinary conditions, all foundations shall be completely dewatered and concrete placed in the dry. However, when concrete placement under water is necessary, all work shall conform to IS:456 and the procedure shall be as follows:
- Method of Placement
Concrete shall be deposited underwater by means of tremies, or drop bottom buckets of approved type.
 - Direction, Inspection and Approval

All work requiring placement of concrete underwater shall be designed, directed and inspected with due regard to local circumstances and purposes. All underwater concrete shall be placed according to specifications approved by the Engineer-in-Charge.

- b) Special precautions shall be taken for prevention of lifting of concrete due to uplift pressure of subsoil water.

4.24 Precast Concrete

4.24.1 General

Precast concrete units, whether manufactured on or off site, shall comply in every way with the provisions of the contract for in situ concrete. Wherever possible, precast units shall be hydraulically pressed. When ready for incorporation in the works, precast units shall be responsible for the accuracy of the level, shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or painted on each unit. Precast concrete shall be as per Basic Engineering design report prepared by the Contractor and duly approved by the Engineer.

4.24.2 Striking Forms

Side shutters shall not be struck in less than 24 hours after depositing concrete and no precast unit shall be lifted until the concrete reaches strength of at least twice the stress to which the concrete may be subjected to at the time of lifting.

4.24.3 Precast Units

The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending stresses to or in the units. Before lifting and removal takes place, contractor shall satisfy the Engineer-in-Charge or his representative that the methods he proposes to adopt for these operations will not over-stress the precast units,

otherwise these operations shall seriously affect the strength of the precast units. The reinforced side of the units shall be distinctly marked.

4.24.4 Curing

All precast work shall be protected from the direct rays of the sun for at least 7 days after casting and during that period each unit shall be kept constantly watered or preferably be completely immersed in water if the size of the unit so permits.

4.25 Slots, Openings etc.

4.25.1 General

Slots, openings, holes, pockets etc., shall be provided in the concrete work in the approved positions or as directed by Engineer-in-Charge. Short pipes with puddle collar shall be fixed in the sidewall of suction pipes. They shall be supplied at the appropriate time during construction. Any deviation from the approved drawings shall be made good by contractor at his own expense, without damaging any other work. Sleeves, bolts, inserts etc., shall also be provided in concrete work where so required.

4.25.2 Grouting

4.25.2.1 Standard Grout

The proportions of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. The grout proportions shall be limited as follows:

Table 10 : Proportions for Standard Grout

Sr.	Use	Grout thickness	Mix proportions	W/c ratio (max.)
1.	Fluid	Under 25 mm	One part Portland cement to one part sand	0.44
2.	General	25mm & over but less than 50mm	One part Portland cement to 2 parts of sand	0.53
3.	Stiff Mix	50mm & over	One part Portland cement to 3 parts of sand	0.53

Sand shall be such as to produce a flowable grout without any tendency to segregate. Sand for general grouting purposes shall be graded within the following limits:

- Passing BIS 2.36 mm sieve 95 to 100%
- Passing BIS 1.18 mm sieve 65 to 95%
- Passing BIS 300 micron sieve 10 to 30%
- Passing BIS 150 micron sieve 3 to 10%

Sand for fluid grouts shall have the fine material passing the 300 and 150 micron sieves at the upper limits specified above. Sand, for stiff grouts, shall meet the usual grading specifications for concrete laitance. Anchor bolts, anchor bolt holes and the bottoms of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose

material. The use of hot, strong caustic solution for this purpose will be permitted. Prior to grouting, the hardened concrete surfaces to be grouted shall be saturated with water. Water in anchor bolt holes shall be removed before grouting is started. Forms around base plates shall be reasonably tight to prevent leakage of the grout. Adequate clearance shall be provided between forms and base plate to permit grout to be worked properly into place. Grouting, once started, shall be done quickly and continuously to prevent segregation, bleeding and breakdown of initial set. Grout shall be worked from one side of one end to the other to prevent entrapment of air. To distribute the grout and to ensure more complete contact between base plate and foundation and to help release trapped air, link chains can be used to work the grout into place. Grouting throughout holes in base plates shall be carried out by pressure grouting. Variations in grout mixes and procedures shall be permitted if approved by the Engineer-in-Charge.

4.25.2.2 Non-Shrinking Grout for Equipment Foundation

Non-shrinking grout shall be used for grouting of machine base plates, anchor bolts, other anchoring devices and at locations where ordinary grouts are ineffective due to shrinkage. It shall be composed of a type of expansive hydraulic sheeting binder and select-graded aggregates. It shall have properties as mentioned below:

Table 11 : Proportions for Non-Shrinking Grout

Sr.	Properties	Values
1	Maximum grain size	6 mm
2	Water % (for 80% flow)	15.17
3	Density of hardened grout	2.27 - 2.30 gm/m ³
4	Compressive strength N/mm ²	
	Minimum 3 days	23
	7 days	34
	28 days	45
5	Expansion %	
	Free	0.10 - 0.20
	Restrained	0.08 - 0.12
	Restrained	0.08 - 0.12

Mixing, batching, cleaning, preparation of surface and curing of non-shrinking grout shall be done as per manufacturer's instructions.

4.26 Inspection

- a. All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer-in-Charge.
- b. All materials supplied by the Contractor and all work or construction performed by the Contractor which is rejected as not being in conformity with the specifications and requirements, shall be immediately replaced.
- c. All concrete shall be protected against damage until final acceptance by the Engineer-in-Charge.

4.27 Clean-Up

- a. Upon completion of the concrete work, all forms, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the premises.
- b. All debris i.e. empty containers, scrap wood etc. shall be removed to "dump" daily, or as directed by the Engineer-in-Charge.
- c. The finished concrete surfaces shall be left in a clean condition satisfactory to the Engineer-in-Charge.

4.28 Records of Concreting

An accurate and up to date record showing times, dates, weather and temperature conditions when various positions of all the concrete structures forming the works were concreted will be kept by the Engineer-in-Charge and shall be countersigned by the Contractor. If the Contractor fails to sign the Engineer-in-Charge's record, it shall nevertheless be regarded as correct and binding on the Contractor.

The Contractor has to submit concrete pour card in duplicate duly to be signed to the Engineer-in-Charge for each type of concreting work. Contractor shall keep copy of it, after Engineer-in-Charge has checked and signed the pour card.

4.29 Supply of Cement

Contractor shall procure / purchase the cement and shall be sacked and well maintained as specified in the earlier sections. Contractor shall procure cement in those quantities required for maximum one month of concreting work and more than the prescribed time limit is not allowed. For any damage to the cement, MCGM will not be responsible and the damaged cement will not be used in the work

4.30 Foundation Bedding, Bonding and Jointing

All surfaces upon or against which concrete will be placed shall be suitably prepared by thoroughly cleaning, washing and dewatering, as specified or as the Engineer-in-Charge may direct, to meet the various situations encountered in the work.

Soft or spongy areas shall be cleaned out and backfilled with lean concrete or compacted clean sand.

Prior to construction of formwork for any item where soil will act as bottom form, approval shall be obtained from the Engineer-in-Charge for the suitability of the soil.

4.31 Preparation of Rock Strata of Foundations

- a. To provide tight bond with rock foundations, the rock surface shall be prepared and the following general requirements shall be observed.
- b. Concrete shall not be deposited on large sloping rock surfaces. Where required by the Engineer-in-Charge, the rock shall be cut to form rough steps or benches to provide roughness or a more suitable bearing surface.
- c. Rock foundation stratum shall be prepared by picking, barring, wedging and similar methods which will leave the rock in an entirely sound and unshattered condition.

- d. Shortly before concrete is placed, the rock surface shall be cleaned with high-pressure water and air jet even though it may have been previously cleaned in that manner.
- f. Prior to placing concrete, the rock surface shall be kept wet for a period of 2 to 4 hours unless otherwise directed by the Engineer-in-Charge.
- g. Before placing concrete on rock surfaces all water shall be removed from depressions to permit thorough inspection and proper bonding of the concrete to the rock.

5 FORMWORK

5.1 Formwork, Fixing and General

- a) All formwork shall be constructed of waterproof plywood or preferably sheet metal. Plywood used for formwork shall be conforming to BIS: 4990 i.e. Specification for plywood for concrete shuttering works. The materials for formwork shall be got approved by the Engineer-in-Charge before starting the work. Formwork shall be firmly supported, adequately strutted, braced and tied to withstand the placing and vibrating of concrete and the effects of weather. The tolerance on line and level shall not exceed 3 mm and the soffits of beams other than pre-stressed beams shall in the absence of any specified camber, be erected with an upward camber of 6 mm for each 3 meters of span.
- b). The Contractor shall be responsible for the calculations and designs for the formwork, and if required, shall submit them to the Engineer-in-Charge for approval before construction. On formwork to external faces, which will be permanently, exposed, all horizontal and vertical formwork joints shall be so arranged that joint lines will form a uniform pattern on the face of the concrete. Where the Contractor proposes to make up the formwork for standard sized manufactured formwork panels, the size of such panels shall be approved by the Engineer-in-Charge before they are used in the construction of the Works. The finished appearance of the entire elevation of the structure and adjoining structures shall be considered when planning the pattern of joint lines caused by formwork and by construction joint to ensure continuity of horizontal and vertical lines.
- c) Faces of form work in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects, and all form work shall be clean and free from standing water, dirt, shavings, chippings or other foreign matter. Joints shall be sufficiently watertight to prevent the escape of mortar or the formation of fins or other blemishes on the face of the concrete and no bleeding should be allowed through the joints.
- d) Form work shall be provided for the top surfaces of sloping work where the slope exceeds fifteen degrees from the horizontal (except where such top surface is specified as spaded finish) and shall be anchored to enable the concrete to be properly compacted and to prevent flotation, care being taken to prevent air being trapped.
- e) Openings for inspection of the inside of the form work and for the removal of water used for washing down shall be provided and so formed as to be easily closed before placing concrete. Before placing concrete, all bolts, pipes or conduits or other fixtures which are to be built in shall be fixed in their correct positions, and cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cut in any concrete without approval of the Engineer-in-Charge.
- f) All exterior angles on the finished concrete of 90 degree or less shall be given 20 mm x 20 mm chamfers unless otherwise ordered by the Engineer-in-Charge.
- f) No ties or bolts or other devices shall be built into the concrete for the purpose of supporting formwork without the prior approval of the Engineer-in-Charge. The

whole or part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be nearer than 50 mm from the surface in the case of reinforced concrete and 150 mm in the case of un-reinforced concrete. Holes left after removal of such supports shall be neatly filled with well-rammed dry-pack mortar.

- g) Formwork in contact with the concrete shall be treated with suitable non-staining mould oil to prevent adherence to the concrete except where the surface is subsequently to be rendered. Care shall be taken to prevent the oil from coming in contact with reinforcement or with concrete at construction joints. Surface retarding agents shall be used only when ordered by the Engineer-in-Charge.
- h) No formwork shall be started or placed unless the reinforcement work is fully completed and checked by the Engineer-in-Charge.
- i) Necessary cover blocks shall be provided before starting concreting.

5.2 Removal of Formwork

- a) Formwork shall be so designed as to permit any removal without resorting to hammering or levering against the surface of the concrete.
- b) The periods of time elapsing between the placing of the concrete and the striking of the forms and loads likely to be imposed on the concrete shall in any case be not less than the periods shown in Table below. Where soffit formwork is constructed in a manner such that during and after such removal of formwork a sufficient number of adequate supporting props are left in an undisturbed condition, then the Contractor may, with the agreement of the Engineer-in-Charge, remove the formwork at the earlier times listed below; provided that the props are left in position.

Table 12 : Period for Formwork

Position of formwork	Days for striking
Walls	1
Sides of beams and columns	2
Slabs (Drops left under)	3
Props to slabs (span not exceeding 4.5m)	7
Props to slabs (span exceeding 4.5 m)	14
Beams soffits (props left under)	7
Props to beams (span not exceeding 6 m)	14
Props to beams (span exceeding 6 m)	21

- c) Notwithstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

- d) Striking shall be done slowly with utmost care to avoid damage to projections and without shock or vibration, by gently easing the wedges. If after removing the formwork it is found that timber has been embedded in the concrete. It shall be removed and made good as specified earlier.
- e) Reinforced temporary openings shall be provided, as directed by the Engineer-in-Charge, to facilitate removal of formwork which otherwise may be inaccessible.
- f) The rods, clamps, form bolts etc. which must be entirely removed from walls or similar structures shall be loosened not sooner than 24 hours not later than 40 hours after the concrete has been deposited. Ties, except those required to hold forms in place, may be removed at the same time. Ties, withdrawn from walls and grade beams shall be pulled toward the inside face. Cutting ties back from the faces of the walls and grade beams will not be permitted.
- g) For liquid retaining structures, no sleeves for through bolts shall be used nor shall through bolts be removed as indicated above. The bolts, in this case, shall be cut at 25 mm depth or more from the surface and then the hole shall be made good by cement sand mortar of the same proportions as the concrete just after striking the formwork.

5.3 Formed Surfaces - Classes of Finish

- a) Finishes to formed surfaces of concrete shall be classified as F1, F2, or F3, or such other special finish as may be particularly specified. Where the class of finish is not specified the concrete shall be finished to Class F1.
- b) Form work for Class F3 finish shall be lined with as large panels as possible of non-staining material with a smooth unblemished surface such as sanded plywood or hard compressed fiber board, arranged in a uniform approved pattern and fixed to back form work by oval nails. Unfaced wrought boarding or standard steel panels shall not be permitted.
- c) Form work for Class F2 finish shall be faced with wrought tongued and grooved boards or plywood or metal panels arranged in a uniform approved pattern free from defects likely to detract from the appearance of the surface.
- d) Form work for Class F1 finish shall be constructed in sheet metal. Surfaces subsequently to be rendered, plastered or tiled shall be adequately scrubbed or hacked as soon as the form work is removed to reduce the irregularities to not more than half the thickness of such rendering, plastering or bedding for tiles and to provide a satisfactory key.

5.4 Defects in Formed Surfaces

- a. Workmanship in formwork and concreting shall be such that concrete shall normally require no making good, surfaces being perfectly compacted and smooth.
 - If any blemishes are revealed after removal of formwork, the Engineer-in-Charge's decisions concerning remedial measures shall be obtained

immediately. These measures may include, but shall not be limited to the following:

- Fins, pinhole bubbles, surface discolouration and minor defects may be rubbed down with sacking immediately after the formwork is removed.
 - Abrupt and gradual irregularities may be rubbed down with carborundum and water after the concrete has been fully cured. These and any other defects shall be remedied by methods approved by the Engineer-in-Charge which may include using a suitable epoxy resin or, where necessary, cutting out to a regular dovetails shape at least 75 mm deep and refilling with concrete over steel mesh reinforcement sprung into the dovetail.
- b. The form work shall be checked by the Engineer-in-Charge before the form work starts and form work found defective shall be rejected and the same can be used after rectifying the defects and with due approval of the Engineer-in-Charge

5.5 Holes to be filled.

- 1 Holes formed in concrete surfaces by form work supports or the like shall be filled with non-shrink high strength grout. The mortar shall be mixed with only sufficient water to make the materials stick together when being moulded in the hands.
- 2 The contractor shall thoroughly clean any hole that is to be filled with dry-pack mortar and where the surface has been damaged, the contractor shall break out any loose, broken or cracked concrete or aggregate. The concrete surrounding the hole shall then be thoroughly soaked after which the surface shall be dried so as to leave a small amount of free water on the surface. The surface shall then be dusted lightly with Ordinary Portland Cement by means of a small dry brush until the whole surface that will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water on the surface. The surface shall then be dusted lightly with Ordinary Portland Cement by means of a small dry brush until the whole surface that will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water by the cement. Any dry cement in the hole shall be removed.
3. The dry-pack material shall then be placed and packed in layers having a compacted thickness not greater than 15 mm. The compaction shall be carried out by use of a hardwood stick and a hammer and shall extend over the full area of the layer, particular care being taken to compact the dry-pack against the sides of the hole. After compaction, the surface of each layer shall be scratched the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

5.6 Tolerances

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

Tolerances for RCC Structures

i. Variation from the plumb

In the lines and surfaces of columns, piers, walls: 5 mm per 2.5 m or 25 mm, whichever is less.

For exposed corner columns and other conspicuous lines

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

ii. Variation from the level or from the grades indicated on the approved drawings

In slab soffits, ceilings, beam soffit, and in arise

In 2.5 m	5 mm
In any bay or 5 m maximum	10 mm
In 10 m or more	15 mm

For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines

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

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

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

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

v. Variation in cross sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus	5 mm
Plus	10 mm

vi. Footings

Variation in dimension in plan

Minus	5 mm
Plus	10 mm

vii. Misplacement or eccentricity 2% of footing width in the direction of misplacement but not more than 50 mm Reduction in thickness: Minus 5% of specified thickness subject to a maximum of 50 mm

viii. Variation in steps

In a flight of stairs

Rise	3 mm
Tread	5 mm
In consecutive steps	
Rise	1.5 mm
Tread	3 mm

Tolerances in other Concrete Structures

ix. All structures

Variation of the constructed linear outlines from established position in plan

In 5 m	10 mm
In 10 m or more	15 mm

Variations of dimensions of individual structural features from established positions

In 20 m or more	25 mm
In buried construction	50 mm

Variation from plumb, from specified batter or from curved surfaces of all structures

In 2.5 m	10 mm
In 5 m	15 mm
In 10 m or more	25 mm
In buried construction	twice the above amounts

Variation from level or grade indicated on approved drawings in slab, beams, soffits, horizontal grooves and visible arises

In 2.5 m	5 mm
In 7.5 m or more	10 mm
In buried construction	Twice the above amounts
Variation in cross-sectional dimensions of columns, beams, buttresses, piers and similar members	
Minus	5 mm
Plus	10 mm

x. Footings for columns, piers, walls, buttresses and similar members

Variation of dimensions in plan

Minus	10 mm
Plus	50 mm

Misplacement or eccentricity

2% of footing width in the direction of misplacement but not more than 50 mm.

Reduction in thickness

5% of specified thickness subject to a maximum of 50 mm

xi. Tolerance in other types of structures shall generally conform to those given in Clause 2.4 of Recommended Practice for Concrete Formwork (American Concrete Institute Act 347).

xii. Tolerance in fixing anchor bolts shall be as follows:

Anchor bolts without sleeves	± 5 mm
Anchor bolts with sleeves	± 5 mm for bolts up to 20 mm dia
3 mm for bolts	above 32 mm dia
Embedded parts	± 5 mm in all directions

5.7 Bracing, Struts and Props

- a. Form work shall be braced, strutted, propped and so supported that it shall not deform under weight and pressure of the concrete and also due to the movement of men and other materials. Bamboo shall not be used as props or cross bearers.
- c. The formwork for beams and slabs shall be so erected that the formwork on the sides of the beams and under the soffit of slabs can be removed without disturbing the beam bottoms. Re-propping of beams shall not be done except when props

have to be reinstated to take care of construction loads anticipated to be in excess of the design load. Vertical props shall be supported on wedges or other measures shall be taken whereby the props can be gently lowered vertically while striking the formwork.

- c. If the formwork for a column is erected for the full height of the column, one side shall be left open and built up in sections as placing of the concrete proceeds, or windows may be left for pouring concrete from the sides to limit the drop of concrete to 1.0 m as directed by the Engineer-in-Charge.

Contractor shall submit the detailed design and methodology with applicable drawings if any of Formwork system for different members for approval of Engineer-in-Charge.

6 REINFORCEMENT

6.1 Relevant IS Codes

IS: 432	: Mild steel and medium tensile steel bars & hard drawn steel wire for concrete reinforcement
IS: 1786	: Cold twisted steel bars for concrete reinforcement (CTD)
IS: 2502 (1963)	: Code of practice for bending and fixing of bars for concrete reinforcement
IS: 55225(1969)	: Recommendations for detailing of reinforcement in RCC works
IS: 2751	: C.P. for welding of MS bars used for RCC
IS: 9417	: Recommendations for welding cold worked steel bars for RCC
IS: 10790	: Methods of sampling of reinforced steel

6.2 General

Reinforcement shall be CTD bars of high strength having corrosion resistance (CRS) as per IS: 1786 grade Fe500 for mechanical properties and shall be Corrosion resistant steel and it shall be either manufactured by TISCO or Vizag Steel or SAIL or Jindal only.

6.3 Storage

- a. The reinforcement shall not be kept in direct contact with the ground but stacked on top of an arrangement of timber sleepers or the like.
- b. If the reinforcing rods have to be stored for a long duration, they shall be coated with cement wash before stacking and/or be kept under cover or stored as directed by the Engineer-in-Charge.
- c. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion and deterioration.
- d. It should be seen that the reinforcement will not be exposed to direct sunlight and preventive measures should be taken for the same.

6.4 Quality

All reinforcement shall be clean, free from grease, oil paint, dirt, loose mill scale, loose rust, dust, bituminous material or any other substances that will destroy or reduce the bond. All rebars shall be thoroughly cleaned before being fabricated. Pitted and defective rebars shall not be used. No welding of rebars to obtain continuity shall be allowed unless approved by the Engineer-in-Charge. If welding is approved, the work shall be carried out as per IS: 1786 – Fe415 / Fe500 according to the best modern practices and as directed by the Engineer-in-Charge. In all cases of important connections, tests shall be made to prove that the joints are of full strength of bars welded. Special precautions, as specified by the Engineer-in-Charge, shall be taken in the welding of cold worked reinforcing bars and bars other than mild steel.

6.5 Laps

Laps and splices for reinforcement shall be as per IS: 456. Splices in adjacent bars shall be staggered and locations of all splices shall be approved by the Engineer-in-Charge.

6.6 Bending

Reinforcement bars supplied bent or in coils, shall be straightened before they are cut to size. Straightening of bars shall be done cold and without damaging the bars.

All bars shall be accurately bent according to the sizes and shapes shown on the approved detailed working drawings/bar bending schedules. They shall be bent gradually by machine or other approved means. Reinforcing bars shall not be straightened and re-bent in a manner that will injure the material; bars containing cracks/splits shall be rejected. They shall be bent cold, except bars of over 25 mm in diameter, which may be bent hot if specifically, approved by the Engineer-in-Charge. Bars, which depend for their strength of cold working, shall not be bent hot. Bars bent hot shall not be treated beyond cherry red colour (nor exceeding 845°C) and after bending shall be allowed to cool slowly without quenching. Bars incorrectly bent shall be used only if the means used for straightening and re-bending is such that it shall not, in the opinion of the Engineer-in-Charge, injure the material. No reinforcement shall be bent when in position in the work without approval, whether or not it is partially embedded in hardened concrete. Bars having kinks or bends other than those required by design shall not be used.

6.7 Fixing

Reinforcement shall be accurately fixed by any approved means and maintained in the correct position shown in the approved Drawings by the use of blocks, spacers and chairs, as per IS:2502 to prevent displacement during placing and compaction of concrete. Bars intended to be in contact at crossing points shall be securely bound together at all such points with number 16 gauge annealed soft iron wire. The vertical distances required between successive layers of bars in beams or similar members shall be maintained by the provision of mild steel spacer bars at such intervals that the main bars do not perceptibly sag between adjacent spacer bars.

6.8 Inspection

After final erection of reinforcement, it shall be intimated to Engineer-in-Charge in writing or through pour cards. Erected and secured reinforcement shall be inspected and approved by the prior to placement of concrete.

6.9 Welding of Reinforcement

- a. Reinforcement which is specified to be welded shall be welded by any process which conforms with the requirements of IS:2751 and which the Contractor can demonstrate by bend and tensile tests will ensure that the strength of the parent metal is not reduced and that the weld possesses a strength not less than that of the parent metal. The welding procedure established by successful test welds shall be maintained and no deviation from this procedure shall be permitted.
- b. Welds in positions other than those shown on the approved Drawings shall not be permitted. Tack welding to lightly secure reinforcement in place will be permitted subject to approval of the Engineer-in-Charge.

6.10 Supply of Reinforcing Bars

Contractor shall procure / purchase the reinforcement and it shall be sacked and well maintained as specified in the earlier sections. Contractor shall procure reinforcement in those quantities required for maximum 1 month of concreting work and more than the prescribed time limit is not allowed. MCGM will not be responsible for any damage to the reinforcement and the damaged reinforcement will not be used in the work.

7 STRUCTURAL STEEL WORK

7.1 Relevant IS Codes

IS: 2062	: Specification for Structural Steel (Fusion Welding Quality)
IS: 800	: C.P. for general construction in steel
IS: 808	: R.S. beam, channel and angel sections
IS: 814	: Covered electrodes for metal arc welding of structural steel
IS: 1148	: Hot rolled steel rivet bars for structural purpose
IS: 1363	: Black hexagon bolts, nuts, and lock nuts (dia 6 to 39mm) & black hexagon screws (dia 6 to 24mm)
IS: 2062	: Structural steel (fusion welding quality)
IS: 3954	: Hot rolled steel channel sections for general engineering purposes
SP-6 (I – VII)	: ISI Handbook for Structural Engineers
SP-40	: Handbook on structures with steel portal frames (without cranes)

7.2 General

Structural steel fabrication work shall include all types of steel structural work required for installation of platform for operation and installation of equipment where rolled steel sections are joined together either by bolting or riveting or welding as specified in the drawings/bill of quantities/directed by the Engineer. It shall also include fabrication and installation of air vessels/pressure vessels etc. Covers for ducts for electrical panels along with their seating arrangements are also classified under this heading unless they are provided separately under a different heading. Reaction tanks or storage vessels are also classified under this heading.

7.3 Materials

The MS structural members such as MS angles, channels, flats, I sections etc. shall conform IS 2062. Structural steel that is used for fabrication shall be conforming to any of the following grades of steel as specified to each of the works:

- IS:226-1975 : Structural steel (standard quality)
- IS:1977-1975 : Structural steel (ordinary quality)
- IS:2062-1980 : Weldable Structural steel (fusion quality)

Whenever the contractor supplies steel, he shall submit the test certificates from the manufacturer.

The welding rods used for fabrication shall conform to IS: 814-1974 (parts I and II). The fasteners like bolts, nuts etc., shall conform to IS: 1367. Rivets shall conform to IS: 1184-1982. Plain washers shall conform to IS: 2016-1967. Spring washers shall conform to IS: 3063-1972.

MS rivets shall conform to IS: 1148 and IS:1929-1967 bolts and nuts shall conform to IS:1363 - 1967.

If metal arc welding is to be done as per design or as ordered by the Engineer-in-Charge the electrodes used for strength welds shall conform to IS: 814 and shall be of such shape and size approved by the Engineer-in-Charge and shall be prevented from oxidation and shall be kept in clean condition.

Paints used shall be of approved manufacture and shade and shall conform to the ISI standards.

7.4 Fabrication and Erection

All the shop drawings shall be prepared by the contractor and submitted in advance of atleast 15 days to the Engineer for his approval. The drawings shall be submitted in triplicate. The fabrication work shall not be taken in hand until the shop drawings are approved by the Engineer. Approval of the shop drawings however shall not relieve the contractor of his responsibility of correct conformation to the designs and fabrications of the structure to meet the requirements of the contract. One copy of the approval drawings shall be given to the contractor for going ahead with the fabrication work.

In the shop drawings to be submitted by the contractor, standard symbols as described in the IS:813-1961 shall be followed.

Fabrication work shall be carried out as laid down in IS:800-1984 Code of practice for general construction in steel.

Welding shall be carried out in accordance with the following specifications as applicable:

- | | |
|----------------|--|
| IS:803 - 1976 | : Code of practice for design fabrication and erection of vertical mild steel cylindrical welded oil storage tanks. |
| IS: 816 - 1969 | : Code of practice for use of metal and welding for general construction in mild steel |
| IS:822 - 1970 | : Code of practice for manual and welding of mild steel |
| IS:9595 - 1980 | : Recommendations for metal are welding of carbon Radiographic tests are required to be carried out as directed by the Engineer in case of pressure vessels. |
| IS:818 - 1968 | : Code of practice for safety and health requirements in electric and gas welding and cutting operations |
| IS:3016-1982 | : Code of practice for fire precautions in welding and cutting operations |
| IS:7205 – 1973 | : Safety code for erection of structural steel work |

The sections shall be fixed absolutely vertical or to the specified angle as shown in the drawings/as desired/directed by the Engineer.

All connections like angle brackets, cleats, gusset plates, anchor bolts, and bearing plates shall all be fixed as shown in the drawings or as directed by the Engineer.

The items of work shall include supply of materials, fabrication and erection in position on site as shown in the drawings. This shall also include all labour consist, materials and equipment required for all fabrication, hoisting, erection, and satisfactory completion of the item of work.

The supply of materials includes all structural members like rolled sections, plates, brackets, rivets, bolts and nuts and welds.

The steelwork shall be painted as specified in the drawings, described in the bill of quantities or as directed by the Engineer. Unless otherwise provided for in the bill of quantities separately, the rate quoted for the item is inclusive of all costs for painting like cost of paint, cost of labour, scaffolding etc. Welding work shall be done generally using electric arcs welding. Where public electricity is not available, generators shall be arranged by the contractor shall be arranged by the contractor himself.

Gas welding shall not be allowed to be resorted to for welding. Under special circumstances if in the opinion of the Engineer it cannot be avoided, gas welding can be done with the prior permission of the Engineer. However gas welding shall not be used where structural strength is the criteria for consideration.

All arrangements shall be made by the contractors for access for inspection by the Engineer or his representative to the workshop where the welding work is being carried out and necessary equipment like gauges, measuring instruments etc., shall be made available to the inspecting personnel.

Painting work shall not be started without the express approval of the Engineer and the painting shall be started only after his inspection and approval of the works after carrying out surface preparations.

All holes shall be carefully marked. Holes shall have their axis perpendicular to the surfaces bored through. Holes being made through two or more members shall be truly concentric. Holes shall not be formed cutting process.

All the temporary connections of parts during assembly shall be done in the following ways for welded structures and tack welding fixtures.

After welding is over, the surface on the joint should be ground and made smooth and even. The welding should be so perfect so as to give required strength as taken for designed purpose at joints in particular. The contractor will make necessary arrangements for testing of joints as required by Engineer-in-Charge.

Welded joints shall be free from defects that would impair the service performance of the construction. All the welds shall be free from incomplete penetration, incomplete fusion, slag inclusion, burns, un-welded creators undercuts and cracks in the welded metal, porosity etc. All the defects shall be rectified as directed by the Engineer. Defective portions shall be removed to the sound metal and re-welded. Rectification of the welds by caulking shall not be permitted.

All welds shall be cleaned of flux and other deposits after completion.

7.5 Painting

Painting shall generally comply with IS subject to addition and alterations as may be prescribed in the special provisions for any particular item. It shall also comply with the requirements of the manufacturer's specifications. One priming coat of red lead shall be

applied immediately after fabrication. Two coats of oil paint of approved shade shall be applied after complete erection. The structural steel to be embedded in concrete shall not be painted.

Inspection and testing shall be carried out in conformity with IS:800.

Riveting, welding and bolting shall not be started until such time as the Engineer has personally satisfied himself that the alignment is correct, in the vertical plumb, the camber correct with camber packs, screwed tight, all joints and cover plates fixed tightened with service bolts and field rivet holes coinciding. While assembling holes in different components shall be made concentric with the use of drills before service bolts are fixed.

Welding if required shall be done as per standard practice and as approved by the Engineer-in-Charge.

All permanent machine fitted nuts and bolts must be perfectly tight and shall be burred or otherwise checked to prevent nuts from becoming loose. No unfitted rivet or bolt holes are to be left in any of the structure.

Structural Steel

All structural steel shall conform to IS:226-1975. The steel shall be free the defects mentioned in IS given above and shall have a smooth finish. The material shall be free from loose mild scale, rust pits or other defects affecting the strength and directly.

7.5.1 General

Engineer's approval shall be obtained before commencing the painting work. All paints and preservatives shall be of approved make and colour and their application shall conform to the manufacturer's instructions. Where more than one undercoat is specified it shall be applied in coats of distinctive tints. Workmanship shall conform to the requirement of IS:2395

Unless the manufacturer's instructions state otherwise 48 hours drying time shall elapse between successive applications of any primer and 24 hours between applications of all subsequent coats. The surface of bituminous paints shall be left at least 3 days before further handling.

No paints in any coats shall be applied until the engineer is satisfied that the surface is clean and dry. And that any previous coat is satisfactory and has hardened adequately. When a surface has been approved, it must be painted immediately.

Paint work shall be rubbed down with a glass paper between coats. No paint shall be applied to a surface, which is damp, dirty or otherwise inadequately prepared.

7.5.2 Ironwork and Ungalvanised Steelwork

Structural steelwork shall be shot blasted to a "white metal" finish, and grease and oil removed prior to painting. Priming shall immediately follow blast cleaning and no cleaned surface shall be left unprimed for more than four hours. Only primers that chemically inhibit corrosion shall be used. Where the iron or steelwork is not in contact

with raw or treated water, the primer shall be red lead complying with IS: 57. Where there is a possibility that the steel or ironwork may come in contact with water, the priming treatment shall be non-toxic, zinc chromate or equivalent. Where it is anticipated that further welding will be required, an approved welding primer shall be applied to the areas to be welded and re primed with the main primer when welding has been completed. Primer coats shall not be less than 0.05 mm each.

After erection, all damaged areas shall be made good, and re primed where the original coat has spread under the primer, the affected surface shall be cleaned down to bare metal to the satisfaction of the Engineer and then re primed.

Repainting shall be carried out as soon as possible after erection. If it is too exposed to weather or condensation, it shall receive one further coat of primer.

Metalwork in intermittent or permanent contact with raw or treated water shall have two finishing coats of approved coal tar pitch epoxy paint such as "Epilux 5" by Berger Paints, or equivalent. The total coating shall be minimum of 0.125 mm thick.

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, be undercoat of synthetic enamel paint conforming-to IS:2932 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.

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.

At least 24 hours shall elapse between the applications of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the Engineer.

8 BRICK WORK AND STONE MASONRY

These specifications deal with all types of brickwork required for buildings, manholes, drains, retaining walls or any construction made out of bricks.

8.1 Relevant IS Codes

IS: 1077	:	Common burnt clay building bricks
IS: 2180	:	Heavy duty burnt clay-building bricks
IS: 2212	:	C.P. for brickwork
IS: 3495 (I – IV)	:	Method of test for clay building bricks
IS: 5454	:	Method of sampling of clay building bricks

8.2 Materials

8.2.1 Bricks

Bricks used for the construction of brick masonry shall be sound, hard, rectangular in shape and size and well burnt of uniform deep red, cherry or copper colour and shall conform to IS: 1077-1986.

The bricks shall be brought from approved brick kilns. The bricks shall be free from cracks, chippings flaws, stones or lumps of any kind. The bricks shall not show any signs of efflorescence and shall be homogeneous in texture.

They should emit a clear metallic sound on being struck and shall have a minimum compressive strength of 50 kg/cm². They shall not absorb water more than specified in the Indian Standard Specifications of its dry weight when soaked in cold water for 24 hours.

8.2.2 Mortar

The proportion of the cement mortar used for the masonry work shall be as specified on the various drawings for different places/types of construction, bills of quantities, and specifications for each part of the work.

Mortar should be prepared by volume using boxes of appropriate sizes on clean platform or metal sheet to avoid mixing of foreign material and maintain consistency of mortar.

Sharp coarse sand is mixed with the required quantity of cement for the preparation of the mortar. Mortar shall be prepared in accordance with IS: 2250-1981. The sand used for the masonry mortar shall meet the requirements as specified in IS: 2116-1980: Sand for masonry mortars. Sand and cement of required proportions are mixed in small quantities in a dry state first and then water is added to make the mortar of required consistency suitable for the type of work it is required as directed by the Engineer-in-Charge. No left over mortar shall be used and therefore only that much quantity of mortar that can be consumed within 30 minutes shall be mixed in batches.

8.3 Construction

The brick masonry shall be constructed as per the Indian Standard Code of Practice for Brick Work - IS: 2212-1962. The thickness of the joints shall not be thicker than those specified in the above Code of Practice.

The bricks shall be thoroughly soaked in water before using them on the work for at least six hours and all the air bubbles shall come out during soaking process. The soaked bricks shall be stacked on wooden planks/platforms so as to avoid sticking of the earth and other materials on to the surfaces of bricks. Bricks required for construction in mud mortar or lime mortar shall not be soaked. Brickwork shall be laid in English Bond unless otherwise specified. Half bricks shall not be used except when needed to complete the bond. Each course shall be perfectly straight and horizontal. The masonry shall be true in plumb in case of vertical walls and in case of battered construction the batter or slope shall be truly maintained. The level of the courses completed shall be checked at every metre interval or less as required.

The bricks shall be laid frogs upwards. While laying the bricks they shall be thoroughly bedded and flushed in mortar and well tapped into position with wooden mallets and superfluous mortar shall be removed.

No part of the structure shall be raised more than one meter above than the rest of the work. In case it is unavoidable, the brickwork shall be raked back at an angle of not more than 45 degrees so as to maintain a uniform and effectual bond, but raking shall not start within 60 cms. from a corner.

In cases of construction of buttresses, counterforts, returns they are built course by course carefully bound into the main walls. At all junctions of walls the bricks at alternate courses shall be carried into each of the respective walls so as to thoroughly unite both the walls together. The brickwork shall not be raised more than 14 courses per day.

All the beds and joints shall be normal to the pressures applied upon them i.e. horizontal in vertical walls, radial in arches and at right angles to the face in battered retaining walls.

Vertical joints in alternate courses shall come directly one over the other and shall be truly vertical. Care shall be taken to ensure that all the joints are fully filled up with mortar, well flushed up where no pointing is proposed, neatly struck as the work proceeds. The joints in faces, which are plastered or painted, shall be squarely raked out to a depth not less than 12 mm while the mortar is still green. The raked joints shall be well brushed to remove the loose particles and the surfaces shall be cleaned with a wire brush so as to remove any splashes of mortar sticking to the surfaces during the construction.

All iron fixtures, pipes, bolts, conduits, sleeves, holdfasts etc., which are required to built into the walls shall be embedded in cement mortar or cement concrete as shown in the drawings/indicated in the specifications directed during the execution by the Engineer-in-Charge as the work proceeds no holes be left for fixing them at a later date unless authorised by the Engineer-in-Charge.

8.4 Curing

Fresh work shall be protected from rain by covering the work suitably. Masonry work as it progresses shall be thoroughly kept wet by watering on all the faces for atleast 7 (Seven) days after completion of the parts of the work. Proper watering cans, flexible pipes, nozzles shall be used for the purpose. The top of the masonry work shall be kept flooded at the close of the day's work by constructing fillets of mortar 40 mm high all around the edges of the top course. In case of fat lime mortar, curing shall start two days after construction of masonry and shall continue for seven days. No additional payment is admissible for curing and the rates quoted are deemed to be inclusive of the cost of curing.

8.5 Scaffolding

Double scaffolding sufficiently strong so as to withstand all loads that are likely to come upon it and having two sets of vertical supports shall be provided. Where two sets of vertical supports are not possible the inner end of the horizontal supporting pole shall rest in a hole provided in a header course only. Only one header for each pole shall be left cut. Such holes, however shall not be permitted in pillars under one meter in width or immediately near the skewbacks of arches. Such holes shall be filled up immediately after removal of the scaffoldings. Safety Code for Scaffolds and Ladders, IS: 3696-1987 (Parts I and II) shall be followed. The cost of scaffolding is deemed to be included in the rates quoted for brick masonry and no separate costs are payable.

8.6 Stone Masonry for Retaining Walls

Stone masonry in general is to be used for retaining walls as per Engineer in-Charge's instructions and as per drawings, which will be supplied during course of construction to suit site conditions.

Following Indian Standards shall be applicable:

IS:1122-1974	Methods of determination of specific gravity and porosity of natural building stones
IS:1200	Method of measurement of stone masonry.
IS:1597	Code of practice of construction of rubble stone masonry.
IS:1805	Glossary of terms relating to stone quarrying and dressing
IS:4101	Stone facing
IS:1121	Determination of strength, properties of natural building stones

8.7 Uncoursed Stone Masonry

Uncoursed stone masonry shall be built in layers not exceeding 450 mm in height. No stone shall be less in breadth than 14 times its height and less in length than twice its height. Every stone whether large or small, shall be laid in its natural bed and set flush in mortar, and the small stones used for wedging or filling being carefully selected to fit the interstices between the large stones. Care shall be taken to see that no dry work or hollow space is left in the masonry. The stones shall be so arranged as to break joints at least every 80 mm and long vertical joints shall be avoided. The joints at the face shall be finished off neatly, being struck and smoothed with a trowel while the mortar is fresh.

The upper surface of the work shall be brought to a uniform level at the height of each course. The faces of masonry walls shall be kept in perfect plumb and where batter has to be given it shall be uniform. The stones at all comers and junctions of walls shall be of large sizes and hammer dressed to the correct angle.

Each stone shall be thoroughly wetted before being used in the work. The masonry shall be kept thoroughly wet during the progress of the work, (care being taken to water it even on Sundays and Holidays, special labour being employed if so required for this purpose) until it becomes hard. As far as practicable, the whole of the masonry shall be raised in one uniform level and no part of the masonry shall be allowed to rise more than 1 metre above the rest to avoid unequal settlement. If raising one part of wall before the other becomes unavoidable the end of the raised portion shall be racked back in steps to prevent cracks developing at the junction of the old and new work. Care shall be taken to see that the sides of the wall are not built separately from the hearting, the faces and internal filling being done simultaneously .The stones shall overlap and cross each other as much as possible. No course shall be laid unless the previous course is perfectly set.

At least one header or through stone per square metre of wall face shall be built into the work. The headers or through stones shall be at least 0.05 m^2 in area at the front face and shall have at least 0.025 m^2 area at the back face. Where the thickness of the wall is more than 600 mm a series of through stones shall be laid through the work so as to form a tie from front to back, breaking joints or overlapping each other for at least 150 mm. No stone whose length is less than 600 mm shall be used in such work as a through stone.

All the through stones shall be marked inside and outside and the marks shall be retained until ordered by the Engineer to be removed. Sufficient number of headers shall be collected on site before commencing any masonry work. Where adequate sized through stones are not available in required quantities, the use of pre-cast plain concrete headers in M-20 mix may be permitted at the discretion of the Engineer. No extra payment will be made for the provision of substitute headers in concrete

Quoins shall be 150 mm high and formed of header stones at least 300 mm long. They shall be laid lengthwise alternately along each face and square on their beds, which shall be dressed to a depth of at least 80 mm.

Weep holes 80 mm wide and 150 mm in height shall be provided in retaining walls at the rate of one per square metre as specified or directed. They shall be pointed with 1:2 cement sand mortar after raking the joints to a minimum depth of 25 mm.

Completed masonry shall be kept wet for a minimum period of 14 days. In wet weather newly laid masonry shall be protected from the effects of heavy rainfall by tarpaulins or other approved material.

8.7.1 Pointing of Uncoursed Masonry

Joints in exposed masonry faces shall be formed while the mortar is still green and shall be finished as flush joints, weathered joints, round-recessed joints or square-recessed joints as directed by the Engineer. Masonry which is to be rendered or plastered shall have the joints raked out to a depth of 15 mm to form a key.

8.8 Stone Pitching

Stone pitching: to slopes shall be carried out where specified or as directed by the Engineer. Stone for pitching shall be obtained from an approved source and shall be hard, sound, durable, clean and generally as specified. The minimum dimension of any stone shall be, at least equal to the specified thickness of the pitching.

After excavation and trimming, slopes to be pitched shall be spread with a 75mm thick layer of crusher run rock or graded coarse aggregate ranging from 75mm particle size to fines. The slope shall then be hand packed with hard broken rock to a total thickness of 150 mm, each stone being individually placed and rammed home, with smaller stones edged into the cracks. 50mm dia weep-holes shall be provided where specified at intervals not exceeding two meter's in both directions. Joints in stone pitching shall be flushed up with sand/cement mortar on completion.

8.9 Rubble Packing

Rubble used for packing under floors, foundations, etc. shall be hard and durable rock, free from veins, flaws and other defects. The quality and size of the rubble shall be subject to the approval of the Engineer.

Rubble shall be hand packed as directed by the Engineer. They shall be laid closely in position on the sub-grade. All interstices between the stones shall be wedged in with smaller stones of suitable size well driven to ensure tight packing and complete filling of interstices. Such filling shall be carried out simultaneously with the placing in position of rubble stones and shall not lag behind.

Small interstices shall be filled with hard clean sand and well watered and rammed.

8.10 Concrete Block Masonry

8.10.1 Materials

Masonry units of hollow and solid concrete blocks shall conform to the requirements of IS: 2185 (Part I).

Masonry units of hollow and solid lightweight concrete blocks shall conform to the requirements of IS: 2185(Part 3).

Masonry units of autoclaved cellular concrete blocks shall conform to the requirements of IS: 2185(Part 3).

The height of the concrete masonry units shall not exceed either its length or six times its width.

The nominal dimensions of concrete block shall be as under.

Length 400, 500 or 600 mm

Height 100 or 200 mm

Width 100 to 300 mm in 50 mm increments

Half blocks shall be in lengths of 200, 250 or 300mm to correspond to the full-length blocks. Actual dimensions shall be 10mm short of the nominal dimensions.

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 ± 3 mm.

Concrete blocks shall be either hollow blocks with open or closed cavities or solid blocks.

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. The bedding surfaces shall be at right angles to the faces of the block.

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.

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 Engineer In Charge.

8.10.2 Workmanship

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 no-load bearing internal walls shall be 100mm. The minimum nominal thickness of external panel walls in framed construction shall be 200 mm.

The workmanship shall generally conform to the requirements of IS: 2572 for concrete block masonry, IS: 6042 for lightweight concrete block masonry and 15:6041 for autoclaved cellular concrete block masonry works.

From considerations of durability, generally concrete block masonry shall be used in superstructure works above the damp-proof course level.

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.

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, leveled and plumb since this will facilitate in laying succeeding 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 cellblocks 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.

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.

As per the design requirements and to effectively control cracks in the masonry, RCC bound beam/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.

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.

At Intersection of walls, the courses shall laid up at the same time with a true masonry bond between at least 50% of the concrete blocks.

Curing of the mortar joints shall be carried out for at least 7 days. The walls should only be lightly moistened and shall not be allowed to become excessively wet.

Double scaffolding shall be adopted for execution of block masonry work.

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.

Concrete blocks shall be stored at site suitably to avoid any contact with moisture from the ground and covered to protect against wetting.

8.11 Damp Proof Course

8.11.1 Materials and Workmanship

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 1:2:1 nominal mix with approved waterproofing compound admixture confirming to IS: 2645 in proportion

as directed by the manufacturer. Concrete shall be with 10 mm downgraded coarse aggregates.

If the surface of brickwork/stone masonry work shall be leveled 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.

Damp-proof course shall be cured properly for at least seven days after which it shall be allowed to dry for taking up further work.

9 PLASTERING

9.1 Relevant IS Codes

IS: 1542	:	Sand for plaster
IS: 1661	:	C.P. for application of ferrous metals in building
IS: 2394	:	C.P. for application of lime plaster finish

9.2 Plastering

Cement mortar used for plastering shall be of the mix proportions and thickness as specified on the drawings or bill of quantities or particular specifications for the various different parts of the works.

The materials used i.e. cement, sand and water shall be of the same quality and of the same specifications as indicated for plain and reinforced cement concrete works in the Section D2 of this tender.

The Polypropylene Fibre shall be mixed in the ratio of 100gm/50 kg bag of cement.

Sand further shall meet the specifications as laid down in IS: 1542-1977 Specification for sand for plaster.

The surfaces that are to be applied with plaster shall be thoroughly cleaned to remove dust, dirt, loose particles, oil, soil, slats etc. that may be sticking to the surfaces. The surfaces shall be washed clean and watered properly for 4 hours before applying plaster.

Scaffolding erected for applying plaster both internally and externally shall be erected independent of the wall to which the plaster is to be applied and in no case the wall shall be pierced by removing bricks.

Plaster shall not, in any case, be thinner than specified. It shall have uniform specified thickness. When smooth finishing is required the cement plastering shall be floated over with neat cement within 15 minutes after application of the last coat of plastering.

The plaster shall be protected from the sun and rain by such means as the Engineer-in-Charge in charge may approve. The plastered surfaces shall be cured for 7 (seven) days. Construction joints in plastering shall be kept at places approved by the Engineer-in-Charge. When the thickness of the plaster specified is to be made up in more than one layer, the second layer shall be applied only when the lower coat is still green. After applying the first layer the surface should be roughed and wherever specified, approved brands of additives like waterproofing compounds shall be added in specified quantities as recommended by the manufacturer of the compound, or as directed by the Engineer-in-Charge.

Wherever scaffolds are necessary for plastering they shall be provided. Stage scaffolding shall be provided for ceiling plaster. To ensure even thickness and true surface, patches of plaster about 15 cms x 15 cms shall be first applied both horizontally

as vertically 2 m apart. Plastering shall be done from top to bottom and care shall be taken to avoid joints on continuous surface.

Sand face plaster shall consist of first layer of 16mm average thick cement plaster in cement mortar 1: 4 (One part cement and Four parts coarse sand). A second layer of 4 mm average thick in cement mortar 1:4 (one part cement and four part coarse sand) shall be applied. After the application of final coat, the surface shall be finished with the application of sponge rubber or as directed to obtain a uniform sand particle surface finish.

In case any other finish like roughcast finish or dry dash finish is specified in the drawings the same shall be provided as directed by the Engineer-in-Charge. Surfaces, which are to be plastered, shall be roughened while they are still green or raked so as to give proper bond between the surface and plaster.

All corner junctions shall be truly vertical or horizontal as the case may be and carefully finished. Rounding or chamfering of corners shall be carried out with proper templates to the required size and shapes.

No additional charges for works like scaffolding curing etc. are payable over and above the rates quoted for brickwork. The rates quoted shall be deemed to be inclusive of all such works.

10 FLOORING

10.1 Relevant IS Codes

IS: 777	:	Glazed earthen ware tiles
IS: 1237	:	Cement Concrete flooring tiles
IS: 1443	:	C.P. for laying & finishing of cement concrete flooring tiles
IS: 2114	:	C.P. for laying in-situ terrazzo floor finish

10.2 General

The materials and workmanship conform to the provisions of the following codes and standards. In particular and with such other standards as mentioned hereinafter. BIS: 269, 385, 515, 653, 712, 809, 1077, 1195, 1196, 1197, 1198, 1237, 1344, 1443.

10.3 Cement Concrete Flooring

10.3.1 General

Flooring shall consist of a sub-base laid on the compacted earth or sand fill as required, a base course laid on the sub-base and then a finishing layer of concrete, Terrazzo or any other material as specified to be laid. The materials for filling (Earth or sand as specified in drawings) shall be brought from the source as approved by the Engineer-in-Charge.

10.3.2 Filling

The surface to receive the filling shall be first cleared free of all roots, vegetation and wetted. Filling in plinth or other specified levels shall proceed in layers of 15 cm. Along with the construction of building, it shall be watered and well rammed in layers as mentioned above and compacted to the satisfaction of the Engineer-in-Charge.

Care shall be taken to remove all roots, vegetation, foreign matter, etc. from the earth used for filling. After thorough consolidation, required quantity of the filling corresponding to the thickness of floor shall be scrubbed to make space for the flooring.

Where sand filling is specified, the sand shall be clean, free from vegetation and other deleterious materials and same procedure followed as for earth filling. In case of sand filling, if required, flooding shall be done to achieve required compaction.

10.3.2.1 Preparation of Bed

The bed for flooring shall be prepared either level or sloped as per relevant drawings or as instructed by Engineer-in-Charge. Care shall be taken that there are no roots, vegetation, foreign matter, etc.

10.3.2.2 Sub-Base

On the prepared bed as indicated above, boulder, or gravel or broken bricks or sand or cement concrete (1:4:8 as per BIS: 465) shall be laid to thickness as specified. This layer shall be beaten with rammers until thoroughly consolidated. All the material used shall conform to the required specifications.

The materials proportion, mixing, laying, and curing, etc. for cement concrete shall be carried out as specified.

The finished work shall be of uniform depth over the whole floor with surface even and parallel to the prepared bed as per drawing or as directed by Engineer-in-Charge.

a. Boulders as Sub-base Course

Boulders shall be laid over the prepared bed as per general specification and shall be of size 100 to 150 mm and shall be of approved quality. Boulders being used shall be free from decay, weathering and be stacked in such heaps in place as directed by Engineer-in-Charge, the thickness being as specified in the relevant drawings.

b. Sand Layer

Sand for sand layer to be laid over the prepared bond shall be clean, free from admixture as per specification. Sand layer shall be spread in one or more layers to the thickness as indicated in drawings or schedule of item watered and rammed.

10.3.3 Base Coarse

10.3.3.1 Cement Concrete

It shall be of specified mix and shall generally conform to "Construction Specification for Cement Concrete".

10.3.3.2 Panels

To prevent construction cracks, the floor space shall be divided into square or rectangular panels. The base course of specified thickness shall be laid in alternate panels or any other pattern as approved by Engineer-in-Charge. The panels shall be of uniform size, not exceeding 4.0 m. in any direction for a floor having thickness 40 mm and above. Alternate panels shall be laid on different days.

10.3.3.3 Shuttering

The panels shall be bounded by glass strips having the same depth as the concrete floor. These shall be fixed in position with their top at proper level, giving slope. The floors shall butt against masonry of wall before it is plastered.

10.3.3.4 Concreting

Cement concrete shall be placed in position with or without MS reinforcements as shown in drawings and beaten with trowel and finished smooth or left rough as directed by the Engineer-in-Charge. Beating shall cease as soon as surface is found covered

with cream of mortar. The surface shall be checked with the help of straight edge and made true.

The shuttering shall be removed next day. Care shall be taken to see that edges are not damaged and fresh mortar from adjacent panels is not splashed over them. The joints between panels shall come out as fine straight line.

MS reinforcement used for concrete base course with reinforcement shall conform to relevant BIS Specifications as detailed in drawings. Before placing of those reinforcements, they shall be cleared of scales with wire brush and oily stains removed.

10.3.4 Floor Finish Plain Cement Finish

Finishing of the surfaces shall follow immediately after the completion of base course. The surface shall be left for some time till the moisture disappears from it. Use of dry cement or cement and sand mixture sprinkled on the moisture shall not be permitted.

Fresh quantity of cement at 2.2 kg per square metre of flooring shall be mixed with water to form thick slurry and spread over the surface, while the concrete is still green. It shall be pressed twice by means of iron floats, once when the slurry is applied and second time when cement starts setting.

The junction of floor with wall plaster, clods or skirting shall be rounded off uniformly where so required upto 25 mm radius or as directed. The men engaged on finishing operations shall be provided with raised wooden platform to sit on, so as floor finish is specified, the top surface of floor finish shall be chequered with mesh or similar impression before the finish has set.

10.3.5 Curing

Each finished portion of floor, on completion, shall be kept wet with ponding or moist sand or moist gunny bags as per specifications. At no time, cement concrete layer, plain or reinforced shall be allowed to dry during curing time.

10.4 Granolithic (IPS) Flooring

The requirement for filling, preparation of bed, sub-base and base course concrete shall be same as in clauses above.

10.4.1 Finished Layers

Granolithic finish of the thickness as indicated in drawings or as specified shall consist of 2 layer of M15 grade cement concrete. The first layer of concrete shall be laid with 10 mm to 6 mm grade aggregate and well compacted. Within 15 minutes of laying this course the second layer with 6 mm down aggregate shall be laid. The cement and aggregates for the top layer shall be mixed dry.

Sufficient quantity of washed sand and water shall be mixed so as to make it plastic but not flowing. This mixture shall be laid on the first layer so that the two layers firmly grip together. The top layer shall be well tamped, spaded, trowelled and finished with neat cement slurry or with non-skid finish as required. At the junction of adjoining panels a thin string shall be given.

The casting of the granolithic finish layer shall be done in rectangular or square panels not exceeding 1.8 M on any side, using glass strips of height equal to the specified thickness of the floor finish. Required slope in the floor shall be given in the base course concrete without reduction in thickness.

10.4.2 Curing

Curing shall be done as per above mentioned clause.

10.4.3 Glazed Tile Flooring

10.4.4 White Glazed Tiles

The glazed tiles shall conform to IS: 777-1970. They shall be flat and true to shape and free from cracks, crazing spots, chipped edges and corners. The glazing shall be of uniform shade.

10.4.5 Size and Tolerance

The tiles shall be of nominal sizes such as 150 x 150 mm and 100 x 100 mm or as specified. The thickness of the tiles shall be 5 mm, or 6 mm as specified. The tolerance on facial dimension value shall be \pm 1.0 mm and \pm 0.5 mm on thickness.

The top surface of the tiles shall be glazed. The glaze shall be either glossy or matt as specified. The underside of the tiles shall be completely free form glaze in order that the tiles may adhere properly to the base. The edge of the tiles shall be preferably free form glaze, however any glaze if unavoidable, shall be permissible on any one edge of the tile.

10.4.6 Coloured Tiles

The sizes and specifications shall be the same as for the white glazed tiles described above. The only difference shall be in the colour.

10.4.7 Decorative Tiles

The type and size of the decorative tiles shall be as follows:

Decorated white background tiles shall be of 152 x 152 x 6 mm and 108 x 108 x 6 mm sizes.

Decorated and having coloured background shall be of 152 x 152 x 6 mm and 108 x 108 x 6 mm sizes.

Fantasy glazed tiles (108 x 108 x 6 mm) other specifications will be the same as that of white glazed tiles.

10.4.8 Preparation of Surface and Laying

Sub grade concrete or the R.C.C slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tile shall be with 1:3 (cement: coarse sand) mortar or as specified, having average 10 mm thickness. The bedding thickness under the tiles shall not be less than 5 mm.

The mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and square on it. Over this mortar bedding neat grey cement slurry of honey - like consistency shall be spread at the rate of 3.3 kg of cement per sq m over such an area as would accommodate about twenty tiles. Tiles shall be soaked in water washed clean and shall be fixed in this grout one after another each tile gently being tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints in between the tiles shall be kept as thin as possible and in straight lines or to suit the required pattern.

The surface or the flooring during laying shall be frequently checked with a straight edge about 2 m long, for obtaining a true surface with the specified slope. Where full size tiles cannot be fixed these shall be cut (sawn) to the required size and their edge rubbed smooth to ensure straight and true joints. The tiles, which are fixed in the floor adjoining the wall, shall enter not less than 10 mm under the plaster, skirting or dado. After laying the tiles the surplus cement grout shall be cleaned off.

10.4.9 Pointing and Finishing

The joints shall be cleaned off the grey cement grout with wire brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the colour of the tiles. The floor shall then be kept wet for 7 days. After curing, the surface shall be washed and cleaned. The finish floor shall not sound hollow when tapped with a wooden mallet.

10.5 Kota Stone Flooring

Kota Stone Slabs- shall be of selected quality hard, sound, dense and homogeneous in texture, free from cracks, decay, weathering and flaws. They shall be hand or machine cut to the requisite thickness and shall be of the colour indicated in the drawings or as directed.

The top (exposed) face of the slabs shall be polished before being brought to site, unless otherwise specified. The slabs shall conform to the size required and samples shall be got approved before starting the work. 20, 30 or 40 mm or specified thickness slabs shall be used.

10.5.1 Tolerances

Of ± 2 mm shall be allowed for the thickness. In respect of length and breadth of slabs, a tolerance of ± 5 mm shall be allowed.

10.5.2 Dressing

Each slab shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth, so that a straight edge laid along the side of the stone shall be in full contact with it. The sides (edges) shall be table rubbed with coarse sand or machine rubbed before paving. All angles and edges of the tiles shall be true, square and free from chipping and the surface shall be true and plane.

10.5.3 Surface Preparation and Laying

Sub-grade concrete on the R.C.C slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 or with lime mortar 1:1:1 (lime putty : surkhi : coarse sand) as given in the description of item. The average thickness of the bedding mortar under the slab shall be 20 mm and the thickness at any place under the slab not be less than 12 mm.

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness as specified. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey -like consistency shall be spread over the same at the rate of 4.4 kg of cement per sq.m. The edge of the slab already paved shall be buttered with grey or white cement with or without admixture of pigment to match the shade of the kota stone slabs as given or specified. The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine joint as possible. All the subsequent slabs shall be laid in the same manner. After each slab has been laid, surplus cement on the surface shall be cleaned off. The flooring shall be cured for at least 7 days.

Slabs, which are fixed in the floor adjoining the wall, shall enter atleast 12 mm under the plaster skirting or dado. The junction between wall plaster and floor shall be finished neatly and without any wavings.

10.5.4 Polishing and Finishing

The floor shall then be kept wet for a minimum period of six days. The surface shall thereafter be ground evenly to the satisfaction of the Engineer-in-Charge with machine grinders in three phases with grade stones from coarse to fine grade. The surface shall receive wash of neat cement mixed with or without pigment and cured before every grinding operation.

After final grinding, surface shall be cleaned and oxalic acid shall be dusted over the surface @ 35 grams. per sq.m.

Cement slurry with or without pigment shall not be applied on the surface before polishing.

10.6 Hardonite Flooring

These specifications cover the guidelines for providing hardonite topping (industrial flooring) for floor subjected to heavy wear and tear viz., pump house, and Generator room etc.

The item includes providing hardonite topping as specified to the thickness and satisfaction of the Engineer-in-Charge, supply of all material, labour, tools and plant required for completing the work in best workmanlike manner.

10.6.1 Workmanship

The person executing the topping shall be an experienced mason familiar with flooring works of similar nature. Flooring shall be laid uniformly, the tolerance for variation of level being + 3 mm.

Hardonite material shall be mixed with cement concrete thoroughly to give a uniform mix.

10.6.2 Preparation of surface

Hardonite shall be laid over a wet concrete surface screened to receive the topping. The base shall be leveled to within + 12 mm.

10.6.2.1 Preparation of topping

Hardonite shall consist of a mixture of cement concrete in proportion of 1:2:4 and well graded iron fillings added in a proportion of 1.50 kg/bag of cement.

10.6.2.2 Application

Hardonite shall be placed uniformly in a layer of specified thickness and finished with a steel troned. Care shall be taken to place hardonite in a separate layer while the base concrete is still wet.

10.6.2.3 Toweling

Surface of floor shall be finished with steel trowel only and trowelled just sufficient so as to give a finished surface.

The surface shall be left for some time till moisture disappears from it.

Toweling shall be done three times at intervals so as to produce a uniform hard surface in no case cement should come up to the surface.

10.6.2.4 Curing

The entire surface shall be kept uniformly wet for seven days.

10.6.2.5 Opening for use

The surface shall be allowed to be used only after curing period is over.

11 DISTEMPERING AND PAINTING

11.1 General

Engineer's approval shall be obtained before commencing the painting work. All paints and preservatives shall be of approved make and colour and their application shall conform to the manufacturer's instructions. Where more than one undercoat is specified it shall be applied in coats of distinctive tints. Workmanship shall conform to the requirement of IS:2395

Unless the manufacturer's instructions state otherwise 48 hours drying time shall elapse between successive applications of any primer and 24 hours between applications of all subsequent coats. The surface of bituminous paints shall be left at least 3 days before further handling.

No paints in any coats shall be applied until the engineer is satisfied that the surface is clean and dry. And that any previous coat is satisfactory and has hardened adequately. When a surface has been approved, it must be painted immediately.

Paintwork shall be rubbed down with a glass paper between coats. No paint shall be applied to a surface, which is damp, dirty or otherwise inadequately prepared.

The Contractor shall review the product manufacturer's special instructions for surface preparation, application, temperature, re-coat times, and product limitations.

The Contractor shall review product health and safety precautions listed by the manufacturer.

The Contractor shall be responsible for enforcing on site health and safety requirements associated with the Work.

Do not begin installation until substrates have been properly prepared.

Ensure that surfaces to receive paint are dry immediately prior to application.

Ensure that moisture-retaining substrates to receive paint have moisture content within tolerances allowed by coating manufacturer. Where exceeding the following values, promptly notify Engineer and obtain direction before beginning work.

Concrete and Masonry: 13 percent. Allow new concrete to cure a minimum of 28 days.

Plaster and Gypsum: 15 percent.

Examine surfaces to receive coatings for surface imperfections and contaminants that could impair performance or appearance of coatings, including but not limited to, loose primer, rust, scale, oil, grease, mildew, algae, or fungus, stains or marks, cracks, indentations, or abrasions.

Correct conditions that could impair performance or appearance of coatings in accordance with specified surface preparation procedures before proceeding with coating application.

PREPARATION - GENERAL

Clean surfaces thoroughly prior to coating application.

Do not start work until surfaces to be finished are in proper condition to produce finished

surfaces of uniform, satisfactory appearance.

Stains and Marks: Remove completely, if possible, using materials and methods recommended by coating manufacturer; cover stains and marks which cannot be completely removed with isolating primer or sealer recommended by coating manufacturer to prevent bleed-through.

Remove Mildew, Algae, and Fungus using materials and methods recommended by coating manufacturer.

Remove dust and loose particulate matter from surfaces to receive coatings immediately prior to coating application.

Remove or protect adjacent hardware, electrical equipment plates, mechanical grilles and louvers, lighting fixture trim, and other items not indicated to receive coatings.

Move or protect equipment and fixtures adjacent to surfaces indicated to receive coatings to allow application of coatings.

Protect adjacent surfaces not indicated to receive coatings.

Prepare surfaces in accordance with manufacturer's instructions for specified coatings and indicated materials, using only methods and materials recommended by coating manufacturer

SURFACE PREPARATION

Concrete and Concrete Masonry: Clean surfaces free of loose particles, sand, efflorescence, laitance, form oil, curing compounds, and other substances which could impair coating performance or appearance.

Concrete Floors: Remove contaminants which could impair coating performance or appearance. Verify moisture transmission and alkaline-acid balance recommended by coating manufacturer; mechanically abrade surface to achieve 80-100 grit medium-sandpaper texture.

Existing Coatings:

1. Remove surface irregularities by scraping or sanding to produce uniform substrate for coating application; apply one coat primer of type recommended by coating manufacturer for maximum coating adhesion.
2. If presence of lead in existing coatings is suspected, cease surface preparation and notify Architect immediately.

Gypsum Board: Repair cracks, holes and other surface defects with joint compound to produce surface flush with adjacent surfaces.

Masonry Surfaces - Restored: Remove loose particles, sand, efflorescence, laitance, cleaning compounds and other substances that could impair coating performance or appearance.

Metals - Aluminium, Mill-Finish: Clean and etch surfaces with a phosphoric acid-water solution or water based industrial cleaner. Flush with clean water and allow to dry, before applying primer coat.

Metals - Copper: Clean surfaces with pressurized steam, pressurized water, or solvent washing.

Metals - Ferrous, Unprimed: Remove rust or scale, if present, by wire brush cleaning, power tool cleaning, or sandblast cleaning; remove grease, oil, and other contaminants which could impair coating performance or appearance by solvent cleaning, with phosphoric-acid solution cleaning of welds, bolts and nuts; spot-prime repaired welds with specified primer.

Metals - Ferrous, Shop-Primed: Remove loose primer and rust, if present, by scraping and sanding, feathering edges of cleaned areas to produce uniform flat surface; solvent-clean surfaces and spot-prime bare metal with specified primer, feathering edges to produce uniform flat surface.

Metals - Galvanized Steel (not passivated): Clean with a water-based industrial strength cleaner, apply an adhesion promoter followed by a clean water rinse. Alternately, wipe down surfaces using clean, lint-free cloths saturated with xylene or lacquer thinner; followed by wiping the surface dry using clean, lint-free cloths.

Metals - Galvanized Steel, Passivated: Clean with water-based industrial strength cleaner. After the surface has been prepared, apply recommended primer to a small area. Allow primer to cure for 7 days, and test adhesion using the "cross-hatch adhesion tape test" method in accordance with ASTM D 3359. If the adhesion of the primer is positive, proceed with a recommended coating system for galvanized metal.

Metals - Stainless Steel: Clean surfaces with pressurized steam, pressurized water, or water-based industrial cleaner.

Plaster: Repair cracks, holes and other surface defects as required to maintain proper surface adhesion. Apply patching plaster or Joint compound and sand to produce surface flush with adjacent undamaged surface. Allow a full cure prior to coating application as recommended by the patching compound manufacturer's recommendations.

Polyvinyl Chloride (PVC) Pipe: remove contaminants and markings with denatured alcohol scuff sand and wipe with solvent for maximum adhesion. Test adhesion before starting the job.

Fiberglass Doors: remove contaminants with cleaning solvent (alcohol) scuff sand and wipe. Test adhesion of primer before starting job.

Textiles - Insulated Coverings, Canvas or Cotton: Clean using high-pressure air and solvent of type recommended for material.

Wood:

Seal knots, pitch streaks, and sap areas with sealer recommended by coating manufacturer; fill nail recesses and cracks with filler recommended by coating manufacturer; sand surfaces smooth.

Apply primer coat to back of wood trim and paneling.

Wood Doors: Seal door tops and bottoms prior to finishing.

Wood Doors - Field-Glazed Frames and Sash: Prime or seal glazing channels prior to glazing.

APPLICATION - GENERAL

Apply each coat to uniform coating thickness in accordance with manufacturer's instructions, not exceeding manufacturer's specified maximum spread rate for indicated surface; thins, brush marks, roller marks, orange-peel, or other application imperfections are not permitted.

Allow manufacturer's specified drying time, and ensure correct coating adhesion, for each coat before applying next coat.

Inspect each coat before applying next coat; touch-up surface imperfections with coating material, feathering, and sanding if required; touch-up areas to achieve flat, uniform surface without surface defects visible from 5 feet (1.5 m).

Remove dust and other foreign materials from substrate immediately prior to applying each coat.

Where paint application abuts other materials or other coating color, terminate coating with a clean sharp termination line without coating overlap.

Where color changes occur between adjoining spaces, through framed openings that are of same color as adjoining surfaces, change color at outside stop corner nearest to face of closed door.

Re-prepare and re-coat unsatisfactory finishes; refinish entire area to corners or other natural terminations.

CLEANING

Clean excess coating materials, and coating materials deposited on surfaces not indicated to receive coatings, as construction activities of this section progress; do not allow to dry.

Re-install hardware, electrical equipment plates, mechanical grilles and louvers, lighting fixture trim, and other items that have been removed to protect from contact with coatings.

Reconnect equipment adjacent to surfaces indicated to receive coatings.

Relocate to original position equipment and fixtures that have been moved to allow application of coatings.

Remove protective materials.

PROTECTION AND REPAIR

Protect completed coating applications from damage by subsequent construction activities.

Repair to Engineer's acceptance coatings damaged by subsequent construction activities. Where repairs cannot be made to Engineer's acceptance, re-apply finish coating to nearest adjacent change of surface plane, in both horizontal and vertical directions.

11.2 Concrete, brickwork and plaster

Where specified to be painted, concrete and plaster shall be rubbed smooth and any cracks, blister holes and other imperfections cut out, filled and made good. The surface shall be dried to the satisfaction of the engineer before painting is commenced and drying time if at least 28 days shall be allowed after laying brickwork and plaster or stripping formwork from concrete. The surface shall be brushed to remove any efflorescence and then painted with the following:

1. For interior brickwork and concrete, apply two coats of oil paint up to 1 meter height and for remaining part two coats of plastic emulsion paint over a coat of primer.
2. For exterior brickwork and concrete, apply two coats of cement based paint over a coat of primer with a water repellent coat of silicate solution of approved make.

Where painting with plastic emulsion is specified, all uneven surface shall be made up by use of putty of appropriate quality, after the surface has been thoroughly cleaned of all dust and dirt and sand papered.

11.3 Ironwork and Ungalvanised Steelwork

Structural steelwork shall be shot blasted to a "white metal" finish, and grease and oil removed prior to painting. Priming shall immediately follow blast cleaning and no cleaned surface shall be left unprimed for more than four hours. Only primers that chemically inhibit corrosion shall be used. Where the iron or steelwork is not in contact with raw or treated water, the primer shall be red lead complying with IS: 57. Where there is a possibility that the steel or ironwork may come in contact with water, the priming treatment shall be non-toxic, zinc chromate or equivalent. Where it is anticipated that further welding will be required. An approved welding primer shall be applied to the areas to be welded and re primed with the main primer when welding has been completed. Primer coats shall not be less than 0.05 mm each.

After erection, all damaged areas shall be made good, and re primed where the original coat has spread under the primer, the affected surface shall be cleaned down to bare metal to the satisfaction of the Engineer and then re primed.

Repainting shall be carried out as soon as possible after erection. If it is to be exposed to weather or condensation, it shall receive one further coat of primer.

Metalwork in intermittent or permanent contact with raw or treated water shall have two finishing coats of an approved coal tar pitch epoxy paint approved by MCGM. The total coating shall be minimum of 0.125 mm thick.

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, be undercoat of synthetic enamel paint conforming to IS: 2932 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.

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.

At least 24 hours shall elapse between the applications of successive coats. Each coat shall very slightly in shade and this shall be got approved by the Engineer.

11.4 Galvanised Steelwork

Newly galvanised steelwork shall be primed with an etch primer such as calcium plumbate. Steelwork that has been galvanised for a long period so that the surface has oxidised adequately to allow adhesion of under-coats, need not have an initial coat of each primer.

After priming, galvanised steelwork in constant or intermittent contact with raw or treated water shall be given two coats of an approved coat of tar pitch epoxy paint approved by MCGM. The total coating shall have a minimum thickness of 0.125 mm.

Protective coats for galvanised steelwork not in contact with water shall be:

1. One coat of micaceous iron oxide paint for interior galvanised steel work.
2. Two coats of micaceous iron oxide paint for external galvanized steelwork.

Galvanised steelwork not in contact with water shall be finished with at least one coat of gloss paint on top of an approved undercoat.

11.5 Bituminous Surfaces

Metalwork items that have been given a shop treatment of bituminous paint shall be painted with two coats of an approved anti-bleed paint before applying a coat of decorative finishing paint.

11.6 Aluminium Surfaces

Aluminum surfaces shall be worked clean, dried and thoroughly degreased before painting, by an appropriate solvent (such as one consisting of equal parts of white spirit and light solvent naphtha). Flame cleaning shall not be permitted. The clean degreased surface shall be treated to ensure paint adhesion either by mechanical roughening, chemical adhesion, or etch primers or wash primers applied in strict conformity with the manufacturer's instructions or by other treatment approved by the Engineer.

The pretreated surface shall receive a priming coat with an inhibiting pigment containing not less than 20% by weight of fine chromate or other approved chromate in a suitable water-resisting vehicle.

The priming coat shall not contain any copper or mercury compounds and it shall also be free from graphite and carbonaceous materials and shall not contain any lead. Priming coat shall consist of a tung-oil phenolic resin which is pigmented with equal parts of zinc tetroxy chromate and red iron oxide.

Aluminum surfaces in contact with concrete, or resting on pads on concrete, shall be painted with two coats bituminous paint, and the concrete surfaces shall also receive two coats bituminous paint.

11.7 Woodwork

Woodwork for painting shall be carefully rubbed down, treated with preservatives and knotted, stopped and primed in the shop. Care shall be taken to ensure that priming is thoroughly brushed into every part of the surface and in particular at end grains, joint and notches where two coats are to be applied. Primers for wood shall be approved by MCGM.

After the woodwork has been fitted and all defects in the surfaces have been made good and re primed, one coat of approved undercoat shall be applied to internal surfaces and two coats to external surfaces. An undercoat approved by MCGM.

'Timber work shall be decoratively finished with one coat of finishing paint approved by MCGM.

11.8 Waterproof Cement Paint

11.8.1 Surface Preparation

The wall should be washed thoroughly with clean soft water and freed of all loose particles, dust, dirt, lichen, moss, efflorescence and Lime wash by Scrubbing with a wire brush. Inequality and holes shall be filled up with cement paste, which should be allowed to set. To get even uniform mat finish it is necessary to keep the surface damp throughout the operation. In hot dry weather the wall should be frequently sprinkled with water to keep it moist.

11.8.2 Mixing the paint

Loosen the contents by either rolling the drum or shaking the container before opening it. Take one measure of water by volume in a clean pot and add two volumes of approved quality waterproof cement paint conforming to IS: 5410. Stir well to make a paste of high consistency then add one more measure of water constantly stirring the mixture. The final composition of water and paint is now 1:1 by volume. Keep stirring the mixture all the time and use it up within an hour. Do not use the mix if it is left over 'for more than two hours.

11.8.3 Method of Application

Wet the surface by any convenient method. A small surface can be wetted by brush. When applying paint surface should be damp and not wet. While applying the first coat brush hard into the surface to cover pores and cavities to ensure better bond. Twelve hours after applying the first coat cure the surface by sprinkling the water. Before applying the second coat damp the surface and after the application of second coat cure it as directed above. In hot climate repeat curing at least twice at the interval of six hours for optimum best results.

11.8.4 Curing

After sprinkling fine spray of water should cure each application paint normally after twelve hours when paint film is hardened satisfactorily. In summer when weather is hot, curing may be done little earlier. Watermarks may be left over the surface if a stream of water is allowed to flow before the paint film is hardened.

11.8.5 Preparation

A solution for application shall be prepared from MCGM approved product. The Manufacturer's instructions shall be followed. This solution shall be prepared to a concentration of about 3 % solids by mixing 1 kg. of water dilatable solution of sodium methyl silicate with 9 kg. of water. Concentration higher than 3% solids are not recommended as they may cause a white precipitate of sodium carbonate formation.

11.8.6 Application

A flooding technique should be used in applying to obtain the best penetration. When spraying, the solution should not be atomized or misted, but flowed on in a solid stream, with the spray gun held, at a distance just enough to eliminate foaming on the masonry surface. If foaming is allowed then certain visible marks might appear after application. The rundown of 150 to 300 mm should be maintained with generous overlapping of passes. Dipping and brushing methods are also suitable. After application of the solution, the treated surface should be allowed to dry at least 24 hours to develop maximum water repellency. This interval may be shortened somewhat by force drying at temperatures to 30 degree C. Though this removes the water quickly, time must still be allowed for the curing. Reaction between the solution and the surface being treated. Until the reaction is complete the applied film still remains water soluble and any rain failing during this time can wash it out. So application should be done in dry weather or at least in absence of rain and fog.

11.8.7 Spraying Equipment

Spraying equipment shall be hand operated stirrup pump with stainless steel nozzle fitted with PVC or polyethylene delivery pipe. Components of the spraying equipment that are in contact with the treating solution should be of black iron, mild steel, stainless steel, Teflon, PVC or polyethylene. They should not be of aluminum or galvanised steel.

11.8.8 Safety

The solution should always be applied in a liquid stream, not by misting or fogging. If misting occurs, avoid inhalation. Contact with the eyes or skin should be treated immediately by flooding the area with large quantities of water for at least 15 minutes.

11.9 Relevant IS Codes

- | | | |
|---------|---|---|
| IS:63 | : | Whiting for paints |
| IS:133 | : | Enamel, interior, undercoating & finishing colour as required |
| IS:2395 | : | C.P. for painting concrete, masonry & plaster surfaces |
| IS:5410 | : | Cement paint, colour as required |
| IS:5411 | : | Plastic emulsion paint for interior use |

11.10 Distempering

11.10.1 Type

Distempering shall be of the oil or water bound type as specified.

11.10.2 Material

Dry distemper or oil bound washable distemper of approved brand and manufacture for water bound and oil bound respectively conforming to IS:426 shall be used. The proportions of the mix shall be as per the approved manufacturer's instructions.

The dry distemper shall be stirred slowly in clean warm water using 8.6 liters of water per kg. of distemper or as specified by the approved makers. The mixture shall be well stirred before and during use to maintain an even consistency.

Thinner as stipulated by approved manufacturer shall be used in case of distemper for oil bound type.

Dry distemper shall not be mixed in larger quantity than is actually required for one day work.

11.10.3 Preparation of Surface and Priming Coat

The surface shall be thoroughly brushed free from mortar dropping and other foreign matter and sand papered smooth.

A priming coat of whiting shall be applied over the prepared surface in case of water bound distempering and distemper primer or cement primer shall be applied in the case of oil bound distemper. The white washing coat shall be used as priming coat for distemper.

11.10.4 Application

After the primer coat is dried for at least four hours, the entire surface shall be coated uniformly with proper distemper brushed in horizontal strokes, immediately followed by vertical ones, which together shall constitute one coat.

Subsequent coats shall be applied in the same way and only after the previous coat has dried. Enough distemper shall be mixed to finish one room at a time. The finished surface shall be even and uniform and shall no brush marks.

After each days work, the brushes shall be washed in hot water and hung down to dry. Old brushes, which are dirty or caked with distemper, shall not be used.

11.11 Decorative Finish Cement Paint

11.11.1 Surface Preparation

Plastered surface shall be thoroughly cleaned of dust, dirt, grease, oil marks, etc. before the coat is applied. All the holes and depressions should be filled with gypsum prior to application of the paint. The surface shall be wet with clean water before paint is

applied. Application of primer shall be as per specifications recommended by approved manufacturer and as directed by the Engineer-in-Charge.

11.11.2 Preparation of Mix and Application

Any approved cement paint shall be mixed in such quantities as can be used up within an hour of mixing. The solution shall be applied on the prepared surface with good quality brushes and no brush mark shall be visible on the finish work.

11.12 Painting

11.12.1 Painting General

Paints, oils, varnishes etc. of approved brand and manufacture conforming to relevant Indian Standard Codes shall be used. Ready mixed paints as received from approved manufacturer without any admixture shall be used. The contractor shall obtain permission for the make and color of the paint he proposes to use and if required, polish for wood work shall be tested as per IS:5807 (parts I and II).

Whenever thinning is necessary, the brand of thinner recommended by approved manufacturer or as instructed by Engineer-in-Charge shall be used. Paints, oil, varnishes, thinner, etc. shall be brought to the site in the original containers in sealed condition and shall be kept in the joint custody of contractor and Engineer-in-Charge.

11.12.2 Commencing the Work

Painting except priming coat shall generally be taken in hand after all other building work is practically finished. Approval of Engineer-in-Charge shall be sought before commencing the work.

11.12.3 Workmanship

All the work shall be carried out wherever applicable as per IS: 1477 (Parts I and II) and IS: 2338 (Part I)

11.12.4 Preparation of Surface

The surface shall be thoroughly cleaned. All dirt, dust, scales and grease shall be removed before painting is started. The surface shall be perfectly dry to permit good absorption. The prepared surface shall receive approval from Engineer-in-Charge for commencing the painting work. For wood surfaces, a priming coat without coloring material should be applied after which all the holes, cracks etc shall be stopped with putty and all knots properly killed with quick lime.

Specially for wood surface, knots if visible shall be covered with red lead conforming to BIS:103. Holes and identification on the surface shall be filled with wood putty and rubbed smooth. Surface should be thoroughly dry.

11.12.5 Application

Paint shall be thoroughly stirred in the container when pouring into smaller containers for use. It shall be continuously stirred while applying on the surface. The painting shall be applied evenly and smoothly in the direction of grains of wood and perpendicular to it. Each coat shall be allowed to dry before the next coat is applied.

Specified number of coats shall be applied and at least 24 hours shall elapse between application of the first coat and the subsequent second coat. No painting shall be carried out on exterior work in wet weather condition or on surface, which are not entirely dry. Each coat shall be lightly rubbed down with sandpaper or fine pumice stone and cleaned of dust before the next coat is laid. No left over paint shall be put back into stock tins.

The finished surface shall be free from hair or brush marks, strokes, clogging of paint puddles in the corners of panels, angles of moulding, etc.

11.13 Painting with Synthetic Enamel/Enamel Paint

11.13.1 Material

Synthetic enamel/enamel paint of approved brand and manufacture and of required shade shall be used for the topcoat only. The paint for under coat shall be of shade to match the topcoat, as recommended by approved manufacturer shall be used.

11.13.2 Preparation of Surface

The surface shall be thoroughly cleaned. All dirt, scales and grease shall be removed before painting started. The surface shall be perfectly dry to permit good absorption. The prepared surface shall receive approval from Engineer-in-Charge for commencing the painting work.

Specially for wood surfaces, knots if visible shall be covered with red lead conforming to IS: 103. Holes and indentation on the surface shall be filled with good putty and rubbed smooth. Surface should be thoroughly dry.

11.13.3 Application

11.13.3.1 Under Coat

One coat of the specified paint of shade matching with the shade of the topcoat shall be applied and allowed to dry overnight. It shall be rubbed next day with the finest grade of wet abrasive paper to ensure smooth and even surface, free from brush marks and all loose particles dusted off.

11.13.3.2 Top Coat

Topcoats of specified paint in the desired shade shall be applied after the under coat is thoroughly dried. Additional finishing coat shall be applied if found necessary to ensure a properly uniform glossy surface.

12 EXPANSION JOINTS AND CONSTRUCTION JOINTS

12.1 General

The item of providing expansion joints and construction joints in concrete includes all the material, labour, tools and plants necessary for completing the item in best workmanlike manner.

12.2 Material

The Material to be used in the joints shall be ribbed PVC water stop of specified width approved by the Engineer, bitumen impregnated fibre board as filler conforming to IS:10566 and approved sealant material (In case of movement joint only). In addition, IS:12220-1987 and 1838 shall also be adhered.

12.3 Joints in Floor

Joints in floor shall be provided as specified on drawings. In case of PVC water stops to be provided horizontal position flat-footed PVC water stops shall be used. The water stops shall be provided in such a way that half the portion of water stop (width wise) is embedded in the concrete and half remains exposed for next concrete. Steel reinforcement shall not be discontinued where construction joints in floor are provided.

12.4 Joints in Walls

12.4.1 Movement Joints

Movement joints shall be provided in the walls at positions shown on drawings. Water stops shall be kept in position with the help of bitumen impregnated fiberboard fillers. Concrete shall be laid in such a way that half the portion of water stops remains exposed for next concreting. Steel reinforcement shall be discontinued at the joints as shown on drawings.

12.4.2 Construction Joints

Construction joints shall be provided between two lifts of concrete as shown on drawings.

A groove shall be formed around exposed portion the PVC waterstop for proper jointing. Care shall be taken during concreting to keep the water stop in vertical position. In no case shall the water stop be punctured or nailed with the binding wire to keep it in position. Wherever required to be jointed the waterstop shall be welded in T, X or L pattern as per the instructions of Engineer.

12.4.3 Complete Construction Joints

These joints are provided in the top layer of the floor of the reservoir with a view to localise shrinkage cracks at these joints. These joints are characterised by complete

discontinuity of steel without any initial gap as in the case of expansion joints. The joints between the adjacent panels of the floor shall be provided with a groove at top of dimension 12 mm x 20 mm and it shall be filled with MC injection series or approved equivalent and they shall be provided with water stops as specified earlier.

The joint between top layer of the floor and the walls or between the top layer of the floor and the column footing, shall also be provided with a groove of 12 mm x 20 mm which shall be filled with sealant material as per specifications given below:

Joint Fillers : Joint fillers shall be of durable, compressible and non-extruding material. It shall be non-staining, non-absorbent and compatible with sealant material used.

Sealant Material : The joint sealing compounds should be capable of properly ensuring water tightness in vertical and horizontal and inclined joints in water retaining and other structures having severe service conditions in respect of anticipated movement or exposure to weather. Typical uses include expansion joints in the walls of water tanks, and in roof and deck slabs exposed to the weather.

The compound should be flexible, durable and weather proof and should have sufficient elasticity to allow joint movements of the concrete components wherever necessary.

The sealant shall be MC Injection Series – Polyurethane Sealing Compound conforming to BS 4254 of 1967 or ASA-A 116-1-1960 or of any other equivalent approved. It shall be capable of cold proof application for horizontal joints and cold application of vertical and inclined joints. The sealing compounds shall be suitable for use in the tropics where it will be subjected to high ambient temperatures, humidity and very strong sunlight. It shall not degrade under these conditions and shall be suitable for use with raw and treated water including water dosed with chlorine. The sealant shall be odour and taint free from lead. It shall be available in choice of colours and shall give a though, permanent seal, be waterproof, non-staining and remain resilient. Sealing compounds for vertical and horizontal joints shall be used complete with the appropriate quantity of primer as per manufacturer's instruction for use. The primers should ensure good adhesion to the concrete and should be specially developed for respective sealing compounds. The sealants shall be applied with pressure guns or without guns as specified by the manufacturers. Sealing compound shall be fully cured before water is permitted to come in contact.

The sealant material should be formulated as to have a storage period of one year at a temperature of 40°C.

The detailed methodology shall be submitted and got approved from Engineer-in-Charge prior to execution of work.

13 EPOXY COATING AND BITUMINOUS PAINTING

13.1 Epoxy Coating

13.1.1 General

Concrete surfaces of the structures shall be provided with protective coatings as directed by the Engineer after successful water tightness test is carried out. It is necessary to take preventive measures against ingress of corrosive forces which induce weathering carbonation of concrete and spalling. This shall be achieved by application of suitable coatings to the surface of reinforced cement concrete.

RCC piers, columns, beams, girders, diaphragms, slabs, parapets etc. shall be coated with epoxy base coating with recommended primer and two coats of epoxy. External surfaces of concrete structures to be buried under the soil shall be provided with protective coating consisting of two coats of coal tar epoxy paint over one coat of primer or anti carbonate acrylic based paints as per manufacturer's recommendations and as directed by the Engineer.

13.1.2 Materials

The materials shall be resistant to sea water and marine soil chlorides, sulphates, oil and grease and shall provide excellent adhesion to concrete surface when tested as per ASTM D 4551.

The materials to be used shall be got approved by the Engineer before placing supply orders. Materials used and process of application to the concrete of other surfaces should be strictly according to the instructions of the suppliers of the epoxy. Mixing of different components shall be as per manufacturer's data sheet. The viscosity should be such that it is convenient for brush application. The materials shall be stored, mixed and applied by brushes or spray as per manufacturers specifications.

13.1.3 Subsurface Preparation

The moisture content of concrete before application of epoxy coating shall not be more than 4%.

Before application of paint the surface should be cleaned to remove dirt, loose particles, laitance, flaking etc. Surface irregularities and blowhole defects shall be rectified by material prescribed by company. Before applying primer coat, the surface shall be cleaned by hard brushes or sand blasting. Primer should be applied thereafter and after 8hrs second coat should be applied.

The coverage shall be in accordance with the manufacturer's recommendations and as directed by the Engineer. DFT shall be checked using digital elcometer. DFT Gauge as directed by the Engineer. In no case the Dry Film Thickness (DFT) at any point shall be less than 190 microns.

13.1.4 Curing

The curing should be done for 7 days at ambient temperature. The instructions of the supplier manufacturer of the product both as for use of materials and application take priority over the above instructions and they should be followed very rightly.

14 DOOR, WINDOWS, GRILLS, SHUTTERS, ETC.

14.1 Relevant IS Codes

IS:1003 (I) :	Timber panelled and glazed door & ventilator shutters
IS:1003 (II) :	Timber panelled and glazed window & ventilator shutters
IS:1038 :	Steel doors, windows & ventilators
IS:1081 :	Fixing & glazing of metal doors, windows & ventilators
IS:1361 :	Steel windows for industrial buildings
IS:2202 :	Wooden flush door shutter (solid core type)
IS:2202 (I) :	Plywood face panels
IS:2202 (II) :	Particle board and hardboard face panel
IS:4020 :	Methods of test for wooden flush doors
IS:6248 :	Metal rolling shutters & rolling grills
IS:7452 :	Hot rolled steel sections for doors, windows & ventilators
IS:10451 :	Steel sliding shutters
IS:10521 :	Collapsible gates
IS:1948 :	Specifications for aluminium doors, windows and ventilators.
IS:1949 :	Specifications for aluminium windows for industrial buildings.
IS:1477 :	Code for hot dipped galvanizing
IS:6243 :	Code for rolling shutter.

14.2 General

The items under this clause cover doors, windows, grills, rolling shutters, collapsible gates etc. normally required to be provided in a building used whether for residential, office, laboratory or industrial purpose.

Doors and windows Shutter shall be of Teakwood as specified in the bill of quantities/drawings or as directed by the Engineer. The sizes of the above items and locations of the same shall be as shown in the drawings.

The frames and shutters shall be of either steel or wood of thickness of members as shown on the drawings. The material used shall be of good quality seasoned timber or specified wood or rolled steel sections as the case may be.

They shall be provided with all necessary fittings like hold fasts, hinges, locking arrangements stoppers, eyes and hooks, tower bolts, handles, fixing lugs etc., of sizes and quality grade as specified.

They shall be provided in complete form including painting, glazing, fixing in position true to level and plumb.

Steel rolling shutters shall be of approved make and shall conform to IS 6248 - 1979. Metal rolling shutters and rolling grills.

The builder's hardware shall all be as per relevant Indian Standards.

14.3 Woodwork in Doors, Windows, Partitions, Louvers, Railings etc.

Wood used for all work shall be the best of the respective class specified, and properly seasoned by at least 6 months air drying, suitable for joiner's work, should be of natural growth, uniform in texture, straight grained, free from sapwood, dead knots, open shakes, boreholes, rot, decay and any and all other defects and blemishes.

The thickness specified for joiner's wrought timbers are, unless otherwise specified, prior to planning and 3 mm will be allowed from the thickness stated for each wrought faces.

All joining shall be wrought on all faces and finished off by hand with sandpaper, with slightly rounded arises.

The joints shall be pinned with hard wood pins and put together with white lead. Jointing shall be by means of mortise and tenon or dovetailed joints as approved.

Any joiner's work which shall split, fracture, shrink, or show flaws or other defects due to unsoundness, inadequate seasoning or bad workmanship, shall be removed and replaced with sound material at the Contractor's expense.

Doors, windows and ventilator frames, transoms and mullions shall be rebated. All dimensions shall be as per drawings. The top framing member of doors and top and bottom framing of windows and ventilators shall project about 10 mm below finished floor. Surface coming in contact with brickwork shall be painted with bitumen as directed by the Engineer-in-Charge. Each of the door and window frames shall be provided with 3 Nos. M. S. 225 x 25 x 6 flat split holdfasts on each side. These holdfasts shall be embedded in masonry of concrete work. The work shall conform to IS: 4021.

The doors shall be paneled or solid flush doors as described in the item of work. All flush doors shall be supplied with approved fittings such as hinges, mortise lock of approved make with handles on both sides, oxidised brass tower bolts and latch arrangements, door stops etc. and as shown in drawings but exclusive of door closers. Door closers, where separately specified shall be of heavy duty hydraulic type to be approved by Engineer-in-Charge. Paneled doors shall have the same fittings except in place of union lock, an aldrop shall be provided. Each door leaf shall have two 250 mm tower bolts, two aluminum or oxidised brass handles, and one doorstopper be made of weatherproof plywood. Flush doors shall conform to IS: 2202 (Part-I).

Doors will generally have no sills but if a few have to be provided, the CONTRACTOR shall do so at no extra cost to the OWNER.

The type of window shall be as specified. Each shutter shall have one pair of hinges, two tower bolts (one 225 mm long and another 150 mm long), one handle and one hook with eye and peg stay. Ventilators shall have two M. S. hold fasts and hinges, one handle and one hook and eye at each and one small tower bolt in the centre. Where so directed by the Engineer-in-Charge, the doors and windows shall be provided with parliamentary type hinges at no extra cost.

The workmanship of all door and window shutters shall conform to the requirements of IS:1003 (Part-I & II) and IS:2202 (Part-I). If required, flush door panels shall be got tested as per IS:4020.

Cupboards, almirahs and shelves shall be provided as per Engineer-in-Charge. The doors could be of either hinged type or sliding type as approved by the Engineer-in-Charge. All dimensions as furnished in the drawings shall be followed. Fixtures and fittings as shown on drawings or as directed by Engineer-in-Charge shall be used.

Railings and architraves shall conform to the shape shown on drawings or as approved and fixed by means of screws (counter sunk or otherwise) or bolts.

The finish expected is of a very high order and the work shall be all-inclusive weather or not all detailed specifications have been spelt out and the work shall be free from blemish.

No iron bars or grills are proposed to be provided in the windows or ventilators. Glass louvered ventilators where specified shall be provided.

Glazed windows, louvers, ventilators and doors shall be provided with either clear or pinheaded glass 5.5 mm thick, which shall be free from all blemishes and shall conform to IS:1761. It should be clearly understood that glass which does not have uniform refractive index or which is wavy will be rejected.

Woodwork shall not be painted, oiled or otherwise treated before the Engineer has approved it.

14.4 Steel Doors, Windows and Fittings

The steel doors, windows, ventilators shall conform or IS: 4351 and IS: 1038. All steel doors windows, ventilators, louvers etc. shall be of sizes as specified and conform to the description in the respective item of work. Whether or not specifically mentioned, all fixtures and fittings necessary for the satisfactory operation of the doors and windows shall be provided. Doors, windows and ventilators shall be obtained from an approved manufacturer. Specific approval for such purchase shall be obtained before hand. Sample shall also be got approved before further manufacture starts, unless this is waived in writing by the Engineer-in-Charge. All steel doors shall be of pressed steel (18 gauge) flush type with or without removable transom. All doors shall be provided with a three way bolting device and locking arrangement with duplicate keys and handles of both sides and operable from either side. The Contractor shall obtain windows with friction hinges in place of windows with peg stays if so directed by the Engineer-in-Charge. For centre hung and top hung ventilators suitable spring catch/pulley and chord arrangement shall be provided for facility of opening. Whenever fly mesh over windows have been called for, they shall be fixed on the window and suitable lever type or rototype arrangement shall be provided for opening or closing of the glazed panels from inside. Prior approval of Engineer shall be taken before order is placed with the manufacturer.

Where specified, steel doors supplied shall be airtight. For this purpose, the Contractor shall provide necessary padding material such as rubber, felt or any other approved material.

14.5 Rolling Shutters

Rolling shutters shall be as per the size to suit the dimensions of the openings shown in the drawing. Unless otherwise specified, they shall be fabricated out of 18 gauge thick G.I. laths of convex corrugation with rolling center either 75mm or 65mm and with minimum 12mm corrugation depth. The laths shall be interlocked by alternate end clips. The side guides shall either be of rolled section or one piece pressed construction and shall be of size 25mm wide, 75mm deep. Thickness shall not be less than 3mm. The shutter shall be provided with bottom lock plate 3mm thick and reinforced by an angle iron stiffener at the bottom and G.I. flat at the top. The suspension shaft shall be of adequate design and unless otherwise specified shall be formed from 8 gauge seamless tube, 60 mm O.D. with suitable flange coupling. The springs shall be of approved high tensile steel flat or coil spring hardened and tempered. These shall be fitted inside the fabricated housing. The ball bearings shall be double self-aligning ball bearings fitted inside CI housing fixed on side brackets holding the suspension brackets at either ends. The suspension of the shutter shall be bolted on specially fabricated cages formed from G.I. flats and plates all are welded. The hood cover shall be made of 20 gauge G.I. sheets with necessary stiffeners and framework. The locking arrangement shall consist of hoop and stable on the bottom plate, lockable from both the sides. Unless otherwise specified, for overall area of rolling shutters up to 5 sqm pull and push type hand operated shutters shall be provided, for area from 5 sq.mtrs. to 10 sq.mtrs. and push type with ball bearings shall be provided and area larger than 10 sq.mtrs. Mechanically operated gear and/or electrically operated shutters shall be provided (Gears will be paid extra). The shutters, hook covers, etc. shall be given 2 coats zinc chromate primer after thorough surface preparation and further 2 coats of paint of approved quality and colour. The erection of these shutters shall be carried according to manufacturer's specifications. While fixing to concrete members, only shelf anchors shall be used. Chiselling of concrete for fixing bolts will not be allowed.

14.6 Collapsible Steel gates

It shall consist of vertical double channels at 10 cm. centers. The size of channels T. Section for top and bottom shall be as per drawing and EIC. The gate shall be provided with necessary bolts, nuts, locking arrangements, stoppers and brass handles on both sides. The gate shall be painted with one coat of anticorrosive paint before erection and two coats of synthetic enamel paint of approved quality and shade. All above material shall be of galvanized iron.

14.7 Aluminium Windows and Doors:

Aluminium doors and windows shall conform to IS:1948 and IS:1949
Aluminium alloy shall conform to IS: 733 and IS: 285. The contractor shall submit the sample of section he is proposing to use for the frame, for approval. He shall also indicate the weight of section per one metre length. He shall also submit for approval the sample of hinges, handles, peg stays or any other items that may require the approval of the Engineer-in-Charge. The contractor shall submit shop drawings for assembly and fixing of doors & windows and fabrication shall be started only after approval to the shop drawings.

The glass panes, unless otherwise specified, shall be of float glass 5.2mm to 5.5mm thickness for windows and 5.5mm thickness for doors and shall be free from flaws,

specks and bubbles. They shall have property squared corners and straight edges. Fixing to frames shall be done with approved glazing pins and approved EPDM rubber gaskets as specified.

Frame consisting of extruded hollow tube sections or other profiles shall be square and flat, the corner of the frame being fabricated to a true right angle.

The hinges shall be either projection type or friction type.

Necessary coupling of approved shape shall be provided for composite windows.

All holes required for fixing frame, for fixing glazing shall be provided. Only brass screws shall be used for fixing the frame to concrete members.

Vertical and horizontal members shall be of adequate rigidity to resist lateral forces. Design calculations shall be submitted for deflection of members.

All the fixtures for center hung shutters, top and bottom hung shutters, or side hung shutters shall be got approved before they are used. The fixtures used should be such that it should be possible to open the shutter to any angle. The pins of hinges shall be of stainless steel of non-magnetic type. Unless otherwise specified, aluminium doors shall be provided with floor springs of approved quality and make.

All aluminium members shall be supplied in either matt or polished finish including anodizing them by electrochemical process to an approved colour and to a thickness of average 20 micron. The frame shall be protected with a layer of clear transparent lacquer based methacrylates or cellulose butyrate. The coating shall be removed after installation is completed and after completing finishing work in the adjoining area.

Where aluminium frames come in contact with steel members, they shall be separated by either a 3mm thick rubber gasket for full width or aluminium member or any other approved film so as to avoid metallic corrosion.

15 HAND RAILING AND RUNGS

15.1 Galvanised Mild Steel Hand Railings

Hand railing and vertical posts shall be made from galvanised mild steel pipes and fittings. The design of the railing shall be approved by the Engineer to whom the Contractor shall submit manufacturer's drawings showing positions of vertical posts, joints, expansion joints and joint details and all fixing details. Fabrication shall not start until these drawings have approved by the Engineer.

Hand railing and vertical posts fabricated from galvanised mild steel pipes and fittings shall conform to the following requirements.

The height of the top railing shall be 1067 mm above finished floor level unless otherwise shown. The lower railing shall 533 mm above finished floor. Subject to the Engineer's approval these and other leading dimensions may be varied slightly to suit manufacturer's standard products.

- a. Unless otherwise shown, handrails and vertical posts shall be made of galvanised mild steel tubes (light class) of 32 mm nominal bore and fittings such as Tee's, Bends, Crossed etc. of heavy class conforming to IS: 1239.
- b. In general the vertical posts shall be spaced at 1.5 metre c/c and shall be built into the concrete or bolted to the MS plate embedded in concrete as shown on detailed drawing.
- c. Hand railing and vertical posts shall be painted with 3 coats of approved paint.

15.2 Stainless Steel Hand Railings

Hand railing and vertical posts shall be made from stainless steel pipes and fittings. The design of the railing shall be approved by the Engineer to whom the Contractor shall submit manufacturer's drawings showing positions of vertical posts, and joint details and all fixing details. Fabrication shall not start until these drawings have approved by the Engineer.

Hand railing and vertical posts fabricated from stainless steel pipes and fittings shall conform to the following requirements.

The height of the top railing shall be 1067 mm above finished floor level unless otherwise shown. The lower railing shall 533 mm above finished floor. Subject to the Engineer's approval these and other leading dimensions may be varied slightly to suit manufacturer's standard products.

- a. Unless otherwise shown, handrails and vertical posts shall be made of stainless steel tubes (grade 304) of 32 mm nominal bore and fittings such as Tees, Bends, Crossed etc. of heavy class.
- b. In general the vertical posts shall be spaced at 1.5 metre c/c and shall be built into the concrete or bolted to the SS plate embedded in concrete as shown on detailed drawing.

15.3 Rungs

Rungs shall be provided in all manholes/inspection chambers/pumping stations over 0.6 mm in depth and shall be of cast iron conforming to IS:5455. These rungs shall be fixed staggered in two vertical runs, 300 mm apart horizontally and 300 mm c/c vertically. The top rung shall be 450 mm below the manhole/inspection chamber cover and the lowest not more than 300 mm above the benching. The rungs shall be of 200 mm diameter with epoxy paint for corrosion resistance.

16 WATER SUPPLY AND SANITARY WORKS

16.1 Applicable Codes

The following standards and codes are made a part of this Engineer-in-Charge. 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 (valve less siphon 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 : 1172	:	Code of practice for basic requirements for water supply, drainage and sanitation
IS : 1786	:	Specification for high strength deformed steel bars and wires for concrete reinforcement
IS : 1239	:	Mild steel tubes (Part I) and mild steel tubular 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 : 2065	:	Code of practice for water supply in Buildings
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 : 3306	:	Specification for chemically resistant glazed stoneware pipes and fittings
IS : 3025	:	Method for sampling and test (Physical and chemical) for water and waste water (Parts 1 to 44)
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

16.2 Sanitary Installation

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 Engineer-in-Charge.

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.

Licensed plumbers shall carry out all sanitary and plumbing work.

All sanitary appliance including sanitary fittings, fixtures, toilet requisites shall be of size, and design as approved by the Engineer-in-Charge.

All white glazed porcelain fixtures, such as washbasin, 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.

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

16.3 Indian Type Water Closet

Water closets shall be white porcelain. Orissa type Indian soil pans, 690mm long conforming to IS: 2556 of approved make and pattern. Flushing cistern of 15 litres

capacity with accessories such as chain, handle, stop tap, brass unions, jamb nuts, overflow pipe and bends, etc. shall be provided.

16.4 European WC (Commode)

European water closets shall be white porcelain or as approved by the Engineer-in-Charge and of approved make and pattern. Flushing cistern of 15 litres capacity with accessories such as handle, stop cock, brass unions, jamb nuts, overflow pipe and bends, etc. shall be provided.

16.5 Urinals

Urinals shall be white glazed flat back type of approved make and of size 430 mm x 260 mm x 350 mm conforming to IS 2556. High level automatic CI flushing cistern of 10 litre capacity as per IS 2326 with necessary CI brackets, GI pipes for water connection from cistern to urinals, stop tap, waste pipe up to CI waste shaft etc. shall be provided.

16.6 Wash Basin

Washbasin shall be of white glazed earthenware conforming to IS 2556 of approved make and of size 560mm x 410mm. The washbasins shall be provided with water supply GI pipe, chromium plated tap, stopcock, CP bottle trap, GI waste water pipe and all necessary accessories and fittings.

16.7 Sinks

Sinks shall be of white glazed earthenware conforming to IS 2556 of approved make and of size 450mm x 300mm x 150mm. The sink shall be provided with CP tap, water supply GI pipe, non-ferrous waste fitting, waste plug and necessary accessories and fittings.

16.8 Cast Iron Soil Waste and Vent Pipes and Fittings

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 pipe 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 materials before being fixed.

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 MS 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.

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 than 7 days by tying a piece of gunny bag kept moist. Joints shall be perfectly air tight as well as watertight.

C.I pipes and fittings, which are exposed, shall be first cleaned and then painted with a coat of red lead primer. 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.

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

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 1800mm or the floor trap is connected to a waste stack through bends.

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

Smoke shall be pumped into the pipe at the lowest end 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.

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

16.9 Asbestos Cement Pipes and Fittings

All Asbestos Cement (AC) soil, waste, vent pipes, and fittings shall conform to IS 1626. The pipes shall have spigot and socket ends. These shall be composed of an inert aggregate consisting of clean asbestos fibre cemented together by ordinary Portland cement conforming to IS: 269, or Portland blast furnace slag cement conforming to IS:455. No organic material shall be added to the composition.

The pipes shall be straight and the ends of the pipes and fittings shall be finished square to their axes. The finished pipes and fittings shall be true and smooth, their inner and outer surfaces shall be concentric. They shall be in all respects sound, homogenous and free from impurities or other imperfections.

The permissible tolerance on the thickness and external dimensions of pipes and fittings including hydraulic test pressure of the pipes and fittings shall conform to IS:1626.

All AC pipes and fittings shall be of approved make and with necessary accessories, wherever required. The diameter wherever approved for pipes and fittings shall be clear internal diameter. All gaps between pipes and fittings and walls shall be filled with cement mortar 1:3 neatly finished. All pipes and fittings shall be supported with standard fixing brackets.

The annular space between the socket and spigot shall be filled with a gasket of hemp and spun yarn soaked in tar. The joint shall then be filled with stiff cement mortar 1:2 (1 cement: 2 fine sand) well pressed with caulking tools and finished smooth on top with near cement paste at an angle of 45°. The joint shall be kept wet for not less than 7 days by typing a piece of gunny bag kept moist. Joint shall be perfectly airtight as well as watertight.

Pipes and fittings shall be tested with a smoke test as approved.

16.10 Galvanised Mild Steel (GI) Pipes

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. The pipe 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.

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.

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.

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 re-threaded, 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-piece 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 to make them slack, water tight joint. The screw thread of pipes and fitting shall be protected from damage until they are fitted.

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 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.

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

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 pipe 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 solids 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 MS pipe sleeve shall be fixed at a place where a pipe is passing through a wall of 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 contact 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 Engineer-in-Charge.

GI 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.

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

The pipes shall be laid on a layer of 10.0 cm sand and sand filled up to 15 cm above the pipes. A sand cushion of 15 cm 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.

The pipes and fittings after they are laid and jointed shall be subjected to hydrostatic pressure test as approved by the Engineer-in-Charge and shall satisfactorily pass the test. Pipeline 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 should be removed and replaced by the Contractor.

The GI pipeline shall be cut to the required length at the position where the meter and stopcock are required to be fixed. The ends of the pipes shall be threaded. The meter and stopcock shall be fixed in position by means of connecting pipe, G.I nuts, sockets, etc. The stopcock 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 pipeline, the pipeline will have to be completely washed before fixing the meter. For the purpose, a connecting piece of pipe equal to the length of the meter is to be fixed on the new pipeline. The water shall be allowed to flow completely to wash the pipeline and then the meter installed as described above by replacing the connecting piece.

16.11 Stoneware pipe and fittings

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.

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

- a. Internal diameter
- b. Grade
- c. Date of manufacture;
- d. Name of manufacture or his registered trademark or both

All pipes and fittings shall have ISI mark jointing of GSW pipes and fittings shall be done as per the requirements of the following Corporation'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 cased, rubber sealing rings are used for jointing, these shall conform to IS: 5382.

16.11.1 Spigot and Socket Joint (Cement Joint)

The Spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. 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 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.

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 then 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 off neatly outside the socket at an angle of 45 degrees.

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

The approximate quantities of cement required for each joint for certain common sizes of pipes are given 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

16.11.2 Spigot and Socket Joint (Rubber Ring Joint)

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 Corporation'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.

16.11.3 Cleaning of Pipes

As soon as a stretch of GSW pipes has been laid complete from manhole to manhole or for a length as approved by the Engineer-in-Charge, 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 Engineer-in-Charge to prevent entry of mud or silt etc.

If as a result of the removal of any obstruction the Engineer-in-Charge considers that damage may have been caused to the pipelines, he shall be entitled to order the length to be tested immediately. Should such a test prove unsatisfactory the Contractor shall repair the pipeline and carry out such further tests as are required by the Engineer-in-Charge.

It shall also be ascertained by the Contractor that each length from manhole to manhole or the length as approved by the Engineer-in-Charge 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.

16.11.4 Testing at Work Site

After laying and jointing of GSW pipes is completed the pipeline shall be tested as per the following Corporation's Requirements and as approved by the Engineer-in-Charge. All equipment for testing at work site shall be supplied and erected by the Contractor. Potable 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 Engineer-in-Charge. Water used for test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer-in-Charge 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 leakage 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.

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 Engineer-in-Charge.

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

16.12 Stop Cock and Bib Cock

Stopcocks and Bibcock's shall be of brass heavy class, chromium plated and of approved manufacture and pattern complying with IS: 781. They shall be of specified size and of the screw down type. The cocks shall open in anti-clockwise direction and chromium plating shall be done in accordance with IS: 1068.

16.13 Soak Pit

Soak pit shall be constructed at the location specified by the Engineer-in-Charge. Earthwork excavation shall be carried out to the exact dimensions. Brick masonry lining with open joints shall be constructed in the pit up to 150 mm below the outlet pipeline. Brick masonry in cement mortar 1:6 shall be constructed above this level up to 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.

16.14 Manholes/Inspection Chambers

16.14.1 Location

Manholes / Inspection chambers shall be constructed at places approved by the Engineer-in-Charge.

16.14.2 Excavation

Excavation, shoring, dewatering etc. for the pits of manholes / Inspection chambers, laying of pipes and fittings/specials shall be done in accordance with Engineer-in-Charge requirements described elsewhere in the document.

16.14.3 Bed Concrete

The bed concrete for manholes/Inspection Chambers shall be done in accordance with Engineer-in-Charge's requirements described elsewhere in the document.

16.14.4 Bricks

Bricks used for construction of manholes / Inspection chambers 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

unground particles and/or which absorb water more than 1/6th of their weight when soaked in water for twenty-four hours shall be rejected. Over burnt or under burnt 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.

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

16.14.5 Cement Mortar

Mortar for brick masonry shall be prepared as per IS 2250, Manholes/Inspection chambers shall be constructed in brick masonry with cement mortar (1:3) 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 Engineer-in-Charge. If required by the Engineer-in-Charge and shall be thoroughly washed till it is free of any contamination.

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. Cement mortar shall be used within 25 minutes of mixing. Mortar left unused in the specified period shall be rejected.

The Contractor shall arrange for tests on mortar samples if so required by Engineer-in-Charge. Re-tempering of mortar shall not be permitted.

16.14.6 Brick Masonry

All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. Brick work 230 mm thick and over shall be laid in English Bond unless otherwise specified. 115 mm 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 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.

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 leveled. The thickness of brick course 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.

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 of all dirt before another course is laid on top. If mortar in the lower course has begun to set, the joints shall be raked out to a depth of 12 mm before another course is laid.

16.14.7 Cement Plaster

All joints in masonry shall be raked to a depth of 12 mm with hooked took 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 wetter 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.

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 IS. 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.

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.

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

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 Engineer-in-Charge.

16.14.8 Cement Concrete Channel

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

16.14.9 Pipe Entering or Leaving Manhole / Inspection Chamber

Whenever a pipe enters or leaves a manhole / inspection chamber, 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.

16.14.10 Cast Iron Steps

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 wrappings. The portion of the step which projects from the wall of the manhole / inspection chamber shall have a raised chequered design to provide an adequate non-slip grip CI 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 a chip of at temperature of 0 degree C.

Where the depth of invert of manhole exceeds 800 mm, cast iron steps of approved pattern shall be fixed in the brickwork 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 CI steps weighing 19 kg each shall be provided at 300 mm vertically in channel of manhole / inspection chamber.

16.14.11 Frame and Covers

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 purchaser
- SEWERS/SWD
- Arrow showing direction of flow

16.14.11.1 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 15.15.10. 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 Engineer-in-Charge. 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 Engineer-in-Charge. 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 / inspection cover and frame shall be painted with three coats of anti-corrosive paint after fixing in position.

16.14.11.2 Fiber Reinforced Concrete Frame and Cover

Fiber 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 fiber-reinforced frame shall have clear opening of 560 mm diameter and weighing 103 kg. The cover shall have a minimum thickness of 100

mm and weighing 78 kg. The fibers 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 fiber reinforced frame and cover shall be manufactured as approved.

16.14.11.3 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 and approved by the Engineer-in-Charge. The frame and cover shall be cast in cement concrete of M20 grades. 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.

16.14.12 Drop Manhole

When a sewer connects a main sewer, and where the difference in level between water line (peak flow levels) or 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 black 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.

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. cascade,
- b. ramp,
- c. By drops in previous manholes.

16.14.13 RCC Manhole

M20 grade of concrete used for construction of RCC manhole shall have minimum cement content of 390 kg/cum of concrete. Minimum cover to the reinforcement shall be 50 mm.

16.15 Vent Shafts

16.15.1 General

Vent shafts shall be erected at such places as approved by the Engineer-in-Charge.

16.15.2 GI Pipe Vent Shaft

GI pipe vent shall be of 100 mm diameter of 'C' class as per IS:1239 and 6 metre height from ground level with slotted cap. The vent shaft shall be embedded in concrete of M10 grade and anchored with a 6mm thick MS base plate of 200 mm x 200 mm.

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 Engineer-in-Charge.

16.15.3 RCC Vent Shaft

Reinforced cement concrete vent shaft shall be of M20 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.

16.16 Septic Tank

The sewer line shall be connected to a septic tank of adequate capacity and design including necessary soak pit. All the works involved, such as excavation, refilling, accessories, fittings, vent pipe, cowl cap, etc. as specified & directed shall be carried out.

16.17 Miscellaneous

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 Engineer-in-Charge.

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

17 APPROACH & INTERNAL ROADS

17.1 Applicable Codes and Specifications

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

Ministry of Surface Transport (Road Wings)	:	Specification for road and bridge works
IS 456	:	Code of Practice for Reinforced Concrete
IRC-6- II	:	Standard Specifications and Code of Practice for Road Bridges- Loads and Stresses
IRC-112	:	Code of practice for concrete road bridge
	:	

17.2 Cement concrete Road

17.2.1 General

Grade of concrete shall be M40.

All concrete works shall comply with IS 456 and the specifications of concrete works specified in these Employer's Requirements.

Data Sheets for Civil Items

Bidders shall furnish item wise information on civil structures in the following format

Item Description	Clear Dimensions (maximum)	No. of storeys	Finishing details	Any other relevant information

Any other Civil Items not covered above

Item Description	Dimensions	Specification and Finishing Details	Any other relevant information

Section 2C

Technical Specifications for Mechanical Works

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SECTION II C – MECHANICAL SPECIFICATIONS

1 SCOPE OF MECHANICAL WORKS

1.1 General

The scope of work for the bidder under mechanical works of the scheme includes design, manufacturing, inspection & testing at manufacturing works, supply, erection / installation at site, testing and commissioning of equipment, systems and accessories at Mogra Storm water Pumping Station. The scope of work further includes comprehensive operation and maintenance for 7 years after successful commissioning of the plant. The bidder should provide his Bill of Quantities with reference to the items and Bill of Material given in this document. The contractor shall carry out his work as per guidelines and specifications given in this tender document. The various Mechanical items for which the contractor has to submit his technical proposal and price bids are given herein. The successful bidder has to prepare and submit General arrangement drawings, technical data sheets and design details for all equipment and accessories and obtain approval of the Engineer prior to proceeding with manufacturing and supply.

In case of any allied missing item the decision of Engineer in Charge shall be followed accordingly.

Wherever reference is made to Indian Standard Specifications, the latest specifications shall be applied. The Scope of Work for which the bidder has to submit his Technical proposal and Price Bid is given below but not limited to the following:-

1.2 Scope of Work for Mechanical Items

The main components of Mechanical works of the Mogra Storm water Pumping Station for the bidder are as under:

1. Coarse Bar Screens with continuous positive raking type mechanical screen cleaning mechanism with local control panel with on-off control station, PLC connectivity, rain protection shed, belt conveyor for carrying the screenings with screenings collection bins complete in all respect.
2. Trash Racks removable L-type for installation inside guide channels provided in the trash rack channel for easy removal by lifting them through guides, with Lifting Arrangement by Travelling Hoist/EOT and Rakes for manual cleaning.
3. Stop logs at upstream and downstream of screens for isolating screens during non-monsoon period and to facilitate maintenance of the screens.
4. Automatically operated Tidal Control Gates including corrosion protection, cathodic protection, control gear box with actuator and manual override along with one set of stop logs.
5. Automatically operated Roller Gates including control gear box with actuator and manual override.

6. Horizontal / vertical axial flow Submersible Storm Water pumps with submersible motors, submersible cable, Mounting Arrangement on Sole plates, Anti-cavitation arrangement, lifting handles, pump monitoring unit with PLC connectivity, emergency stop complete in all respect.
7. Automatically operated centrally hinged type Flap Gates including control gear box with actuator and manual override.
8. Diesel engine driven power generation sets (minimum 4 nos., working) of required power generating capacity with control panel, AVR, emergency stop, PLC connectivity, acoustic enclosure, engine exhaust chimney, Hot air exhaust arrangement as per tender specifications and as per design requirements of the Storm Water Pumping Station complete in all respect.
9. Auxiliary D.G. Set of required power generating capacity as per design requirements of the Storm Water Pumping Station and as per tender specifications with AMF panel, emergency stop, PLC connectivity, acoustic enclosure, engine exhaust chimney arrangement complete in all respect
10. Fuel Transfer System from Main Diesel Tanks to Day Tank including pumps, piping, level sensors, control valves, vents, local control panel, PLC connectivity etc. complete in all respect for D.G. Set (Main) & DG set (Aux.)
11. Day tanks & Fuel Transfer System from Day Tank to D.G. Sets (Main) including level sensors, PLC connectivity, control valves, vents, return pipeline etc. complete in all respect
12. Day tank & Fuel Transfer System from Day Tank to D.G. Set (Aux) including level sensors, PLC connectivity, control valves, vents etc. complete in all respect
13. Gantry crane / EOT Crane of SWL capacity minimum twice the max. weight of equipment / component to be lifted, as per specifications for lifting and shifting of Coarse Screens, Trash racks, Stop Logs, screen panels along with additional provision of grab arrangement of volume equivalent to 1.25 m³ (min) adequate to remove silt, deposits, rags, tree branches, debris from silt trap upstream of screens, with cabin operation facility including control panel, cables, maintenance platform, caged ladder and allied works
14. Gantry crane / EOT Crane of SWL capacity minimum twice the max. weight of equipment / component to be lifted, as per specifications for lifting and shifting of Tidal Control Gates, their Stop logs and super structure with cabin operation facility including control panel, cables, maintenance platform, caged ladder and allied works
15. EOT Crane of SWL capacity minimum twice the max. weight of equipment / component to be lifted, as per specifications for lifting and shifting of horizontal / vertical axial flow submersible pumps, including rail section complete with Control pendant, control panel, cables, maintenance platform, caged ladder, extension structure and allied works.
16. Ventilation system for Toilet blocks and Pantry.

17. Submersible dewatering Pump with lifting chain and guide pipe, delivery pipes, valves, local control panels etc. complete for dewatering of pumps bays, silt pit and screen area.
18. Fire Fighting system including fire hydrant, valves, pumps / raw water tank, control panel, alarms etc. complete as per specifications and as approved by Fire Officer
19. High pressure water jet cleaning arrangement including stand posts, piping, pumps, valves and specials etc. complete with raw water tank and pumps for cleaning of inlet bay, silt pit, pump bays, Tidal Control Gate area and Screen area.
20. Pump sets for potable water tank / raw water tank

1.3 As Built Drawings

After completion of manufacturing, installation and commissioning of all Mechanical works mentioned above, prior to commencement of Operation and Maintenance period, the Contractor shall prepare and submit to MCGM, six complete sets of As-built Drawings – two sets on RTF and four sets on A1 size drawing paper and all four sets and all sets shall be laminated; and one set of the drawings in soft form on the USB drive. As-built Drawings are the Detailed Engineering Drawings showing the actual details according to which the Construction/Fabrication/Erection has been carried out. The contractor shall have to obtain approval of the As-built Drawings from MCGM.

2 GENERAL TECHNICAL SPECIFICATIONS FOR MECHANICAL WORKS

2.1 Introduction

This General Technical Specification sets out the general standards for design, submission of drawings, materials, workmanship, inspection and testing, packing and shipment, storage, protection, erection at site, O & M manual, spares and tools etc. of components, equipment, accessories and the Facilities to be supplied by the Contractor. Mention of any specific Plant and Equipment does not necessarily imply that it is included in the Facilities.

All component parts of the Facilities shall, unless specified otherwise in the Particular Technical Specification (Chapter 3), comply with the provisions of this Standard Technical Specification. The Engineer of Contract shall have power to reject any Plant and Equipment which in his opinion is unsatisfactory or not in accordance with this Specification and such Plant and Equipment shall be replaced by the Contractor at no extra cost to the Buyer.

The names of the manufacturers proposed by the Contractor for incorporation in the Facilities for Equipment and accessories which are not covered in the list of approved makes shall be submitted by the Contractor together with technical data sheets, drawings, performance, capacities, certified test reports, list of successful installations and other significant information including details of manufacturing facility shall be provided for consideration by the Engineer of the Contract.

2.2 General Requirements, Workmanship and Design of Goods

All Equipment and Accessories shall be new, manufactured with sound workmanship, shall be robust in design for a long and reliable operating life and suitable for intended application. Design features shall include the protection of equipment / accessories against damage caused by vermin, dirt, dust and dampness and to reducing risk of fire. All equipment and accessories and the pumping facility as a whole shall operate without undue vibrations and parts shall be designed to withstand maximum stresses by the most severe conditions of normal service. Wherever necessary, suitable anti-vibration measures shall be provided.

All Equipment and accessories shall be designed to permit safe operation and maintenance.

The general design of all Equipment and accessories and particularly that of the bearings and other wearing parts shall be governed by the need for long periods of service without frequent maintenance and attention being necessary.

Unless otherwise specified, all items of Plant and Equipment shall be rated for continuous service at the specified duty conditions under the prevailing atmospheric and operational conditions on Site.

All parts subject to wear shall be readily accessible for maintenance and replacement purpose.

Provision shall be made for taking up wear in all bearings and other wearing parts or for easy replacement if adjustment is not practicable.

The duty speed range of rotating shafts shall be well below the first critical speed of the shaft. Where a change in diameter of the shaft occurs the shoulder shall be generously radiused to reduce stress concentration.

In the opinion of the Engineer of Contract, if any moving parts of the equipment or accessories show signs of undue wear or unsuitability for the purpose for which they were installed, they shall be deemed to be defective materials workmanship or design and shall be replaced.

Suitable spacers and/or shims shall be fitted for ease of adjustment and re-alignment of all machinery units; particular attention shall be given to combined sets.

Where fitted bolts, spigots or other means for precise location are not employed in the assembly of the Plant and Equipment, locating dowels shall be fitted on completion of erection, to the satisfaction of the Engineer of Contract.

All components parts of the Plant and Equipment shall be strictly manufactured to close tolerances and thereby offer complete interchangeability of similar parts.

Unless otherwise specified, the Contractor shall make provision in accordance with his standard practice, for the prevention of corrosion and erosion in any part of his Plant. Such provision shall include the use of suitable materials, choice of operating speeds, design of components and type of protective coatings and finishes.

All items of Plant and Equipment for which spare parts may be required shall have attached to them un-tarnishable metal plates clearly showing the manufacturer's name, serial numbers and basic information as to rating, etc, in sufficient detail to allow the unit or assembly to be identified in correspondence and when ordering parts.

Identification name and no. shall be prominently inscribed on each item of Plant and Equipment and its corresponding Control panel for reference in a manner to be approved by the Engineer of Contract. e.g. 'Submersible Pump No. 2'.

Standard Specifications

Where reference is made in this Specification to a Standard Specification the Plant and Equipment concerned shall comply with the latest / current edition of Standard Specification (six weeks before the date for the Submission of Bids unless otherwise stated in this Specification).

All Plant and Equipment supplied and workmanship performed in regard to which standard specifications have been issued by the International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC) shall be supplied and performed in accordance with such standard specification unless otherwise specified in this Specification or approved by the Engineer of Contract even though the standard specification is not referred to in this Specification.

Use of any alternative relevant authoritative internationally recognised equivalent reference standard at no extra cost to MCGM may be permitted provided the

Contractor submits copies of specified and relevant standards, proof of previous suitable use for review and assessment of the Engineer at the stage of approval of designs and drawings. However, Engineer's decision in this regard shall be final and binding on the Contractor.

Where reference is made in this Specification to a manufacturer's products such reference shall be taken only as an indication of design and quality.

2.3 Submission of Drawings/design sheets/Data sheets

Drawing Submission

The Contractor shall submit the following detailed drawings for review and approval of the Engineer of Contract.

- i) Detailed Design Calculation sheets for all mechanical works/equipment and accessories.
- ii) General arrangement drawings for all equipment to be supplied.
- iii) Technical Specification / data sheets showing rating, make, details and quantity of various components used in specific mechanical item / assembly.

Form of Drawings

Every drawing shall provide legible details and should have a title block in the right bottom corner showing following minimum details.

Client	MCGM
Consultant	
Contractor	
Equipment Manufacturer	
Equipment model and sl. No.	
Project Name & Location	
Drawing Title	
Location	
Drawing Number	
Revision Number	
Date of submission	
Designed by	
Date of approval	

Approval of Drawings/Documents/Technical Data Sheets

- a) Drawings, Technical data sheets and relevant submissions shall be approved by the Engineer prior to manufacturing.
- b) The review of design calculations and drawings shall be carried out only in respect of orientation and sizes of important members, general design principles and approach, adherence to requirements of the relevant IS or other statutory codes, compliance with the technical specifications given in the tender document, general or specific notes and with the requirements of good engineering practice. Check for any interference and taking remedial action is the responsibility of the contractor.
- c) Approvals should be done after discussion across the table when needed with Consultant and MCGM to avoid delays in submission in revisions. Approval by the Engineer of Contract of the contractor's design or drawings shall not relieve the contractor of any of the contractual obligations or liabilities under the contract or his responsibilities for correctness of dimensions, material of construction, weights, quantities, design details, assembly fits, performance particulars and conformity of the supplies with the Indian statutory laws as may be applicable.
- d) Should it be required at any time after approval has been given by the Engineer of Contract that any drawings or documents submitted by the contractor are not consistent with any technical data, drawings or documents submitted or approved previously or substantially deviate from any major aspect of the contract, then such alterations or additions as may be deemed necessary by the Engineer of Contract shall be made therein by the contractor and the works carried out accordingly without any extra cost.
- e) The contractor shall make no revision after a design, drawing or documents is "approved for manufacturing" by the Engineer of Contract. In case the contractor desires to incorporate any amendments in an "approved" drawing, he shall resubmit the same for formal approval giving reason for the change required.
- f) Contractor shall be responsible for preparation and submission of drawings and designs complete in all respects as per the requirements of the technical specifications and the scope of work and as per sound engineering practices. Non-compliance with this requirement may result in repeated revisions and resubmissions of drawings / designs resulting in time loss for which the Contractor shall be solely responsible.

2.4 Inspection and Testing during Manufacturing

- a) The Contractor shall submit Manufacturing and Testing / Inspection Quality Assurance Plan for each equipment / accessory prior to proceeding with the manufacturing, for approval of the Engineer of Contract / his representative.
- b) The Contractor shall offer each item of Plant, equipment and accessories for inspection, examination and witness testing at the manufacturing facility of the respective manufacturer. He shall inform the representative of the Engineer of Contract / his representative, of the date when the Plant and Equipment will be ready for inspection and witness testing, well in advance.

- c) If the tests are beyond the resources of the manufacturer he shall make arrangements for these to be carried out elsewhere. Any variation / deviation of this requirement shall be agreed and confirmation in writing obtained from representative of the Engineer of Contract / his representative.
- d) The Contractor shall provide to the Engineer two unpriced copies of purchase orders / work orders for all Equipment and accessories including those manufactured at his own works. The orders shall indicate the Facilities for which the Equipment / accessory is required, state in details about the inspection and test requirements, material of construction and approved G.A. drawing reference, give sufficient information for ready identification and shall state that all items will be subject to witness inspection and performance test unless waived by the Engineer of Contract / his representative for that Equipment.
- e) Unless the witness testing is waived, in writing, all the item of Plant, Equipment and accessories shall be offered for witness testing and inspection to the Engineer or his representative. Witnessed testing may be waived on standard types of small Equipment / accessories or for small components used in the manufacture of Equipment and accessories made by the approved manufacturers. The Contractor should apply to the Engineer of Contract or his representative, when submitting orders, for witnessed testing to be waived on standard items of Plant and Equipment.
- f) The Contractor shall give reasonable notice to the Engineer of Contract or his representative of the date when each item of Plant and Equipment is ready for inspection and witnessed testing. Prior to calling for inspection / testing, the Contractor should carry out their internal inspection/ testing and should submit their internal test report for review of the Engineer of the Contract / his representative.
- g) The Contractor shall carry out tests as stated in the current appropriate ISO, IEC or specified Standard, performance tests and such other tests as are necessary in the opinion of the Engineer of Contract / his representative, to determine that the Plant and Equipment comply with the Specification either under test conditions in the manufacturer's Facilities, on Site or elsewhere in the ordinary working.
- h) Four copies of all test certificates and performance curves etc. shall be supplied to the Engineer of Contract / his representative within two weeks of completion of any witnessed tests, or when witness tests are not required within two weeks of the manufacturer's tests or within two weeks of the instructions to waive witness tests being received with respect to type tests.
- i) On each test certificate sufficient information to enable the Engineer of Contract / his representative to issue a release certificate, including the contract number and details, shall be given for ready identification of the Plant and Equipment to which the certificate refers.
- j) Where tests and inspection have been completed to the Engineer of Contract's / his representative's satisfaction, and when the test certificates, test results, performance curves etc., have been checked / verified, the Engineer of Contract / his representative will confirm acceptance in writing and the Plant and Equipment shall not be delivered until this Acceptance has been received.

- k) The Employer reserves the right to require the Contractor to meet any extra costs which are occasioned by failure of the Contractor to comply with the above testing and inspection requirements, including the provision of test certificates, curves, etc., or, which in the opinion of the Engineer of Contract, are due to insufficient care having been taken by the Contractor before presenting the Plant and Equipment for inspection or test. If unauthorised delivery has taken place the Contractor may be required to arrange for the Plant and Equipment to be returned to the manufacturer for inspection and/or witness testing by the Engineer of Contract / his representative at the Contractor's expense.
- l) All apparatus, instruments and connections required for the tests, measurement of parameters shall have been duly calibrated for accuracy not less than six months prior to the tests.

2.5 Protection and Packing during Shipment and storage at site

All Plants, Equipment and accessories while shipment and till they are installed in intended position shall be adequately protected and packed in accordance with the approved standard. In addition the Plant and Equipment shall be so protected as to be safe from spoilage, damage and corrosion until it is installed and commissioned at site.

All the items of Plant and Equipment which are finished painted at the manufacturer's works such as switchboards, shall be suitably encased in wooden structure and individual equipment / accessory should be securely fixed to wooden frame using appropriate method for their protection during shipment..

Particular care shall be taken in the packing of electrical apparatus. It shall be packed separately in sealed polythene or similar approved bags (including liberal supply of desiccant) taking all precautions to exclude moisture.

Packing cases shall be strongly constructed using tongued and grooved boards with internal and external battens. Each packing case shall be durably marked with the Contract number and site address and such other markings as may be directed.

The Contractor shall make good to the satisfaction of the Engineer of Contract any deterioration of the protective coatings, damage to equipment / accessories or their components or shall arrange for replacement of equipment or accessories in case of damage beyond repair or in case of loss or theft which may occur during transportation, loading –unloading or during storage at site.

An area on site will be identified by the Contractor for storage of all equipment / accessories till the time of installation. The Contractor shall provide all facilities for safe and proper storage, as recommended by the manufacturers, with particular consideration given to temperature, rains, sunlight, wind and ground conditions. No equipment / accessories shall be stored directly on ground. Items shall be handled and stored in a manner that they are not subjected to excessive stresses and their protective coatings are not damaged.

A shed is to be provided at site to protect the supplied equipment from external environment and damage.

2.6 Contractor's Equipment, Engineering personal and Labour

The Contractor shall, at his own expense, provide all equipment, tools, meters, gauges, temporary accommodation, skilled and unskilled labour, required for the execution of supply, site inspection, erection / installation of individual equipment and of the Plant as a whole, covered by the Contract.

Suitable qualified and competent specialist personnel shall be employed for:

- (a) Incoming inspection of all equipment / accessories.
- (b) Installation / Erection of the Plant and Equipment and checking for its correctness.
- (c) The necessary liaison with the Engineer of Contract in respect to measurement of work, submission of day work sheets / Installation protocol etc.
- (d) Site testing of all equipment / accessories.
- (e) Commissioning of all equipment / accessories and the plant as a whole

The Contractor shall not remove any supervisory staff or skilled labour from the Site without the Engineer of Contract's prior approval.

2.7 Equipment Erection and Installation

The Contractor shall be responsible for setting up and erecting the Plant and Equipment to the line and level required, at its desired location in required manner as per approved methodology and approved drawings and shall be strictly done in line with manufacturer's instructions.

In case of equipment foundations, wedges and packing shims (MS packing shims shall not be used) shall provide at least 30 mm clearance for grouting. After correct alignment and levelling the foundation bolts shall be nipped up to hold the item of Plant and Equipment firmly in position. It shall be the Contractor's responsibility to check that its position and alignment is maintained during and after the grouting is completed.

After the grouting has set hard the foundation bolts shall be fully tightened and the alignment and level rechecked. The Engineer of Contract shall be informed at all times of the progress of this work and when any checks on alignment and level are to be carried out so that he may witness the checks if he so requires. The approval of the Engineer of Contract or his intimation that the alignment or level of the Plant and Equipment is to his satisfaction shall in no way relieve the Contractor of his obligations under the Contract to properly install and align the Plant and Equipment and shall in no way prejudice the Engineer of Contract's rights to order the rectification of any installation work later found to be improperly carried out. The Contractor shall submit Installation Protocol duly signed by his site engineer and manufacturer's engineer for approval by the Engineer of the Contract.

Throughout his period of attendance on site the Contractor shall employ a mechanical engineer who shall be present on site at all times while work is in progress. The engineer shall not be changed or withdrawn from site without the written approval of the Engineer of Contract. Throughout the contract period, the Contractor shall attend

regular site meetings with the Engineer of Contract's staff to discuss all matters related to the Facilities and installation and commissioning of mechanical and electrical works.

The Contractor shall liaise and cooperate fully with the Engineer of Contract to ensure that all Facilities progress safely and in accordance with the overall project programme. At each site meeting the Contractor shall identify his future programme and any interference or delay which may result from other activities in the vicinity of his Services.

2.8 Inspection and Testing at Site

When the Contractor is satisfied that all the Plant and Equipment supplied is erected and in good working order, he will be required to demonstrate to the Engineer of Contract the erection and operation of the installed Plant and Equipment.

On completion of erection all pipelines shall be tested to ensure tightness of joints and connections to a pressure agreed between the Contractor and the Engineer of Contract. Test pressure will not exceed the relevant Standard Specification requirements unless otherwise specified.

The Plant and Equipment will be inspected to establish its performance in accordance with the approved technical data sheets and to ensure compliance with the Specification. In the event of any item of Plant and Equipment failing to meet the requirements of the Specification or the final workmanship being defective the Contractor shall take immediate remedial steps and rectify the deficiency to the satisfaction of the Engineer of Contract.

2.9 Protection of Goods

All Plant and Equipment supplied to site shall be provided with adequate protection against corrosion, mechanical damage, deterioration, fire, loss of items, damages due to rains etc. All such Plant, Equipment, accessories or components may required to be returned to the manufacturer's works at the Contractor's expense for making good any damage or deterioration etc., which may have occurred, until the Plant and Equipment is given Operational Acceptance.. The Contractor shall submit his proposals for achieving this protection for the approval of the Engineer of Contract.

The Contractor shall make good to the satisfaction of the Engineer of Contract any deterioration of the protective coatings, paintwork, etc., which may occur during transportation, erection, Site testing, operation, etc., until the Plant and Equipment is given Operational Acceptance.

Finish painting of the Plant and Equipment at Site, as specified, shall be carried out before the Plant and Equipment is given Operational Acceptance.

All parts which are not epoxy painted shall be hot dip galvanized. Hot dipped galvanizing shall be carried out in accordance with BS 729 with a deposition rate of at least 610 g/m². After galvanising all parts shall be passivated to minimise discolouration. All fixing bolts, washers, nuts and other items for supports and fixings shall be spun galvanised.

2.10 Operation and Maintenance Manuals

The contractor shall submit 5 copies of operating instructions and maintenance manual of individual equipment / accessories to the Engineer-in-charge at the time of delivery at site.

Information supplied by the manufacturers employed by the contractor shall be coordinated into a comprehensive manual. The instruction manual shall describe the installation procedure as a whole and shall give a step wise instructions for any operation likely to be carried out during the life of each item of the plant including the erection, commissioning, testing, operation maintenance, dismantling and repair.

The manual shall include, but be limited to the following:

- Where applicable, fault location charts to facilitate tracing the cause of malfunction or breakdown.
- A section dealing with procedures for ordering spares.
- Technical Data sheets Specifications of equipment, General arrangement drawings
- Schedule of preventive, maintenance, calibration and repair instructions.
- Parts list and spare parts recommendations
- Safety precautions to be taken while handling different units and First aid instructions
- Do's and don'ts for equipment operation. Operator's attention shall be drawn to all operations considered to be dangerous or likely to cause damage to the plant.
- A complete list of recommended lubricants, oils and their charts.

2.11 Spares

Spares of individual equipment and accessories shall be manufactured as per specifications to strict limits of accuracy and shall be readily interchangeable with the parts they replace.

The Contractor shall prepare a list of commissioning spares and regular spares required for individual equipment and submit it to the engineer for his approval. He shall not allow them to be sent by suppliers direct to Site. The Engineer of Contract may require to inspect the spares and packaging before dispatch. During operation and maintenance period of 7 years contractor shall maintain requisite spares and tools on site on continuous basis. No stoppage of operation and maintenance of any equipment for non availability of spares and tools at any time shall be accepted.

Spares shall be packed and well protected for long term storage in accordance with ISO Guide 41. Associated Electrical components / equipment shall be sealed in polythene or similar bags with a liberal supply of desiccant. Each package shall have attached to it an embossed metal plate giving information for identification. This shall

include the manufacturer's name and reference description as shown on the approved drawings.

The packages of items of spares shall be collected together by the Contractor into consignments of reasonable size and then packed in secure cases each of which shall contain a contents list. Each case shall be durably marked with the contract number and Site address and shall be sent to Site after detailed instructions for despatch have been received from the Engineer of Contract.

2.12 Special Tools

- (i) The Bidder shall arrange and use all kind of special tools and tackles as required during installation / erection, commissioning and during comprehensive operation and maintenance period of all the equipment, accessories and plant on his own.
- (ii) The Engineer of Contract may require to inspect the tools and packaging before despatch and the Contractor shall hold them and not allow them to be sent by suppliers direct to Site.

2.13 Materials

Material shall have high resistance to change in their properties due to the passage of time, exposure to light, temperature and any other cause which may have detrimental effect on the performance or life of the works.

Stainless steels used for welding shall be a grade not subject to intergranular corrosion.

Prevention of seizure, by fretting where two corrosion resistant metals are in contact, shall be by selection of suitable relative hardness and surface finish and/or lubrication.

Where bronze is specified, or used, it shall be zinc free.

Dissimilar metals in contact shall be selected so that the electrolytic potential difference does not exceed 0.6 volt unless the surface area of the lower potential metal is negligible. Alternatively an approved insulation material shall be used.

When the Engineer of Contract requires the submission of material samples for assessment they shall be submitted by and at the expense of the Contractor not less than thirty calendar days prior to the time that the material is required for incorporation into any Plant and Equipment. Samples shall be subject to written approval by the Engineer of Contract and shall not be used without such approval.

2.14 Welding

In all cases where welds are liable to be highly stressed the Contractor shall supply to the Engineer of Contract before fabrication commences detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Engineer of Contract has signified his approval of the details proposed. No alteration

shall be made to any previously approved detail of weld preparation without prior approval of the Engineer of Contract.

Mechanical and other non-radiographic tests, if required, shall be carried out in the presence of the Engineer of Contract.

All welded constructions shall be heat treated to relieve residual stresses prior to finish machining.

2.15 Forgings

All major stress-bearing forgings shall be made to a standard specification which shall be submitted to the Engineer of Contract for approval before work is commenced. They shall be subject to internal examination and non-destructive tests for the detection of flaws, and shall be heat treated for the relief of residual stresses. The name of the maker and particulars of the heat treatment proposed for each such forging shall be submitted to the Engineer of Contract. The Engineer of Contract may inspect such forgings at the place of manufacture with a representative of the Contractor.

2.16 Balancing

All complete rotating assemblies shall be dynamically balanced. Balancing shall be done strictly in accordance with ISO 1940/1 and quality shall not be less than G6.3

2.17 Bolts, Screws, Studs, Washers and Nuts

All bolts, screws, nuts and washers shall be of stainless steel grade SS 304.

Bolts shall be of sufficient length and generally two to three threads shall show through the nut when in fully tightened condition.

2.18 Fixing Bolts

Fixing bolts, nuts and washers for concrete, brick or masonry shall be of stainless steel the bolts may be rag or indented bolts, expansion bolts, or resin bonded bolts. The Contractor shall submit details of the type he proposes to use, including manufacturer's specification literature, for the Engineer of Contract's approval.

When the bolts etc., are used for fixing aluminium items they shall be insulated from the aluminium by a non-metallic sleeve and under-washer.

The building-in material for use with rag or indented bolts, shall be a proprietary epoxy non-shrink grout or a proprietary non-shrink mortar or caulking compound. Bolts shall not be brought into service until they are effectively anchored and the building in material has achieved adequate strength.

2.19 Lubrication

The positions of all greasing and oiling points shall be arranged so as to be readily accessible for routine servicing. Where necessary, to achieve this, suitable extension pipes shall be fitted.

Manual grease lubrication points shall use hexagon headed nipples. If more than one type of grease is required, a different size of nipple shall be used for each type and labels fitted to indicate the special lubricant required.

Oil bath type lubrication systems shall be provided with sight glass type level indicators.

Dip sticks or level plugs shall not be used without the approval of the Engineer of Contract.

Automatic lubrication shall be provided where specified and full details of the systems shall be submitted to the Engineer of Contract, for approval.

Where continual grease or oil feeding is required the capacity of the reservoir shall be sufficient for not less than seven days continuous service.

A complete schedule of recommended lubricants shall be included in the Operating and Maintenance Instructions for the Plant and Equipment.

2.20 Name Plates, Labels and Warning Notices

All equipment shall be suitably and uniformly labeled. Each equipment should carry a name plate giving major technical details of that equipment as to its operation. .

Warning notices, whether statutory or otherwise, shall be provided in appropriate locations to warn personnel of any potential hazard caused by the equipment.

Details of all labels and warning notices shall be submitted to the Engineer of Contract prior to manufacture.

Labels and warning notices shall be of engraved stainless steel plate and shall be screwed or bolted in position. Adhesive bonding is not acceptable.

2.21 Safety Guards

All sections of the plant which constitute a safety hazard shall be covered by substantial guards or barriers. All rotating equipment should be provided with guards wherever necessary.

All parts that in normal working are hotter than 60°C or colder than -5°C shall either be adequately fenced or shall be tagged.

All live electrical loads including conductors forcing parts of electrical apparatus shall be properly insulated. All high voltage electrical apparatus / panels shall be fenced / provided with restricted access. Danger boards indicating shall be placed in front these panels in legible format, written in English and Marathi language.

All Guards shall be fully enclosed type be fabricated in mild steel sheet.

Guards shall be designed to provide ready access to bearings, greasing points, thermometer pockets and other check points to allow routine observations to be made by the operating staff without danger or the need to dismantle any part of the guard.

Hinged doors let into the guards with padlocking facilities shall be provided where necessary to facilitate access to the check points.

Guards shall be bolted in position in such a way that they cannot be unintentionally dismantled or removed.

All mild steel used in the construction of guards, including bolts, nuts, washers and brackets shall be hot dip galvanised unless otherwise specified.

Drawings of safety guards shall be submitted to the Engineer of Contract for approval before manufacture.

2.22 Pipe work

Pipe work shall include all necessary specials, jointing materials, flange adapters, etc.

The layout and design of the pipe work shall be such as to facilitate its erection and the dismantling of any section for maintenance.

Where a common manifold pipe is used, individual pump delivery branches unless otherwise shown on the Specification drawings shall be jointed to it in a horizontal plane and radiused or angled to prevent sharp changes of flow.

At joints in civil engineering structures, flexibility shall be provided in pipe work to accommodate differential settlement.

All pipes of 50 mm dia. or above connected to items of plant shall have flanged connections.

All pipes shall be checked for alignment and mating of flanges and connections before being secured. Pipes shall not be sprung into position.

Adequate supporting and anchoring arrangements for all pipes shall be provided and particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated plant. Where concrete supports are required, the Contractor shall indicate these on his drawings and the necessary work shall be arranged by the Engineer of Contract. The design of the concrete supports shall be the responsibility of the Contractor. The design calculations shall be submitted to the Engineer of Contract if requested.

2.23 Galvanised Steel Pipe work

Steel pipes of 50 mm bore and below may be supplied with screwed and socketed joints. All other joints shall be made with screwed on NP25 flanges. The screwed on flanges and joints shall be made and protected with zinc chromate paste.

Walkway Platforms, Access Steps, Ladders and Hand Railing

The ladders, platform, covers and handrails to be supplied and fixed under this Contract are indicated on the Drawings or detailed in the Specification.

Any small areas of chequer plating or similar covering that are necessary to cover gaps between items of Plant and the surrounding structure, and any access ladders, platforms and handrails that must be attached to items of Plant to facilitate operation, inspection or maintenance, shall be supplied and erected by the Contractor.

The Contractor shall include in his Contract for providing adequate means of access to all handwheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance.

Handrails shall consist of double ball forged steel standards with tubular rails, hot dip galvanised in accordance with BS EN ISO1461.

Chequer plating shall be of 'Durbar' or other non-slip pattern, not less than 4.5 mm thick (exclusive of pattern) and hot dipped galvanised after fabrication in accordance with BS EN ISO 1461.

Walkways and Access Platforms:

Standard structural steel sections shall be used for the support structure.

Toe plates shall be fitted along the outer edges of all walkways and shall be part of the structure and not the floor panels. Toe plates shall extend 100 mm above the top level of the floor panels. Floor panels shall be sized so that each panel does not weigh more than 50 kg.

The support structure shall be constructed so that it can readily be dismantled. Provisions shall be made in the design for adjustment to eliminate irregularities in structural floor levels.

All components including floor fixings shall be galvanised after fabrication.

All assemblies shall be marked at the factory with distinguishing numbers, letters or marks corresponding to those of Approved Drawings or parts lists. Such marks if impressed before painting shall be clearly readable afterwards. Any temporary bolts for field erection shall be readily distinguishable from any bolts used for permanent connections.

Where dissimilar materials come into contact with each other an insulating membrane or paint coating shall be applied to minimise direct contact.

All components shall be hot dip galvanised after fabrication in accordance with BS EN ISO 1461.

Access Ladders:

Where access ladders are provided as part of a structural steelwork installation they shall comply with the following requirements. The cross-section of the stringers shall be suitable for the weight of the ladder, taking into consideration the spacing of the points at which they are fixed to supporting steelwork or floors. The minimum thickness of the stringers shall be 12 mm. The stringers shall be drilled to take the 20 mm diameter rungs, which shall be uniformly spaced at between 230 and 260 mm centres. The rungs shall pass through and be welded to the stringers at each side of each

stringer, and each weld shall be continuous. Supports shall be arranged to allow a minimum clearance of 200 mm behind the rungs to the wall or other obstruction.

Access ladders and all fittings shall be hot dipped galvanised after fabrication in accordance with BS EN ISO 1461.

Chequer Plating

Chequer plating complete with cut-outs and in sizes suitable for removal by hand shall be of galvanised steel of sufficient thickness to carry a loading of 10 kN/m². Deflections shall not exceed 0.005 of the span and if the spans are over 1 m stiffeners shall be used.

Plating shall be of non-slip, self-draining pattern securely fixed to the supporting structure. The sections shall fit without gaps and squarely on the supporting structure.

The weight of each removable section shall not exceed 50 kg.

Each length shall have two formed holes for lifting keys. Two pairs of lifting keys shall be supplied for every 10 m² of plating. Where a single area is covered by several pieces of plating the direction of the pattern on all plates shall be the same and the pattern shall be continuous.

Curbing shall be built in so as not to reduce the width of the opening and it shall provide a minimum of 25 mm bearing surface for the chequer plating. It shall be supplied with fixing lugs at centres, not exceeding 1 m. Curbing and chequer plating shall be finished flush with the surrounding finished floor.

Chequer plating shall be screwed to its curbing or supporting steelwork by countersunk screws so that individual plates cannot rattle or move. At the edges of raised floors, gangways and platforms toe plates 100 mm high shall be provided.

2.24 Joints

Screwed joints on galvanised pipes shall be made and protected with zinc chromate paste.

Victaulic joints may be provided on pressure pipes where necessary to facilitate removal of valves, etc., but not on pipelines where internal pressure may fall below atmospheric in these situations 'Viking-Johnson' couplings or flanged adapters with rubber seals shall be used. Adequate provision shall be made for anchoring pipes at these joints.

2.25 General Valve Requirements

All valves shall carry a unique identification number and/or plates stating the valve manufacturer, the valve identification and a brief description of the valve function.

All valves shall have a local visual identification of valve status. This shall clearly show whether the valve is open, closed or in some intermediate position.

Valve handwheels shall be cast iron with the direction of opening/closing cast into the handwheel. All valves shall be clockwise closing. Pressed steel handwheels will not be accepted.

The maximum effort required to operate any valve fitted with a standard handwheel shall not exceed 200 N.

Valve Materials

Valve bodies and other components shall be of corrosion resistant materials, compatible with the media being conveyed, and of robust industrial design.

The valve stem, thrust washers, screws, nuts and other components exposed to the media shall be of a corrosion resistant grade of bronze or stainless steel.

All cast iron valves shall have high tensile brass spindles, gunmetal nuts, gates with gunmetal faces and seats, and bronze gland bushes. All spindle seals shall be fitted with soft packed glands.

Gates covered with nitrile rubber shall have stainless steel spindles.

Set screws and body/bonnet bolts shall be fitted with 'O' Ring seals.

Valve Identification

Each valve shall be identified by a unique reference which shall identify the process controlled, and be numbered as agreed with the Engineer of Contract.

The relevant reference shall be either engraved on a 3 mm thick laminated white/black/white traffolyte disc or stamped on a 1 mm (19 g) thick brass disc. The discs shall be at least 35 mm diameter with reference letters and numerals not less than 4 mm and 8 mm high respectively.

The discs shall be mounted on the hub of the handwheel or where this is impractical, they shall be attached to the valve stem by means of suitable brass 'S' hooks and/or jack chain through a hole at the top of the disc.

Valve Testing

All electrically actuated valves shall be tested, with their respective actuators, to demonstrate smooth, trouble free operation between fully open and fully closed position.

The Contractor shall provide test certificates for all materials of major valve components including; bodies, gates, discs, spindles and seatings.

The following hydrostatic pressure tests shall be carried out, with the valve fully assembled, in the presence of the Engineer of Contract and in accordance with ISO 5208:-

- (i) Body test to 1.5 times the rated pressure of the valve.
- (ii) Open ended seat test at the rated pressure of the valve. Isolating valves shall be tested in both directions. The leakage rates shall not exceed the values given in the relevant Standard Specification or stated in the Detailed Specification.

2.26 Pump Testing

All pumps shall be tested at the manufacturer's works as per the applicable standard specifications.

2.27 Gearboxes

Where driven plant requires a drive system incorporating a speed reducing or increasing gearbox, the drive system shall be supplied by the driven equipment manufacturer.

Unless stated otherwise in the Detailed Specification, all electric drive motors shall be TEFC type with IP 55 protection and shall be designed for operation voltage variation of 415 V +- 10 % and the frequency variations will not exceed $\pm 5\%$. Unless specified, each motor shall be fully tropicalised and suitable for operation in the prevailing climate conditions.

The gear type used shall be determined by the driven plant manufacturer unless stated otherwise in the Detailed Specification. The gear form shall be in accordance with the relevant ISO or AGMA standard. The gear load carrying capacity for strength and wear shall be determined in accordance with the relevant ISO or AGMA standard but the following parameters shall be taken as a minimum.

- (i) 24 hours per day operation
- (ii) Service factor of 2.0 based on the rated output of the respective prime mover.
- (iii) Rated life of 50 000 hours

The surface hardness of gears shall be determined in accordance with the relevant ISO or AGMA standard and for case hardened gears the depth of case shall be not less than 0.4 mm after profile grinding to counteract distortion.

The gears shall be enclosed in a cast or fabricated case. Fabricated steel cases shall be stress relieved prior to final machining. The case shall be split or provided with covers to facilitate inspection of the gears without dismantling the shafts.

Shaft bearings shall be selected with a rated life of 50 000 hours at the maximum speed and power rating of the gears. Any end thrust from the gears shall be accommodated by the shaft bearings.

Input and output shafts shall be adequately sealed to retain lubricant and prevent ingress of contaminants under all operating conditions.

Drain and filling plugs shall be provided. Where necessary extension tubes shall also be provided to facilitate filling and draining. Breathers shall be provided with filters to prevent ingress of dust and moisture etc.

Oil lubricated gearboxes shall be fitted with a sight glass indicating both the hot and cold oil levels. This item is included for reference only if bidder proposes to use in this project.

Each gearbox shall be equipped with an embossed nameplate including at least the following information:

- (i) Manufacturer's name
- (ii) Gearbox type reference
- (iii) Serial or Order Number
- (iv) Power rating of gears
- (v) Speed ratio
- (vi) Lubrication specification (type and viscosity)

2.28 Piping Work

Relevant IS Codes

IS: 3114	:	Code of practice for laying CI pipes
IS: 5822 for pipes	:	Code of practice for laying of welded steel
IS: 7364 (part I – III)	:	Plastic pipe work for potable water supply

2.29 General Specifications for CI Piping Work

Cast Iron Pipe and Specials

1. All CI Pipes and specials supplied for this contract shall confirm to the following specifications:
 - a. IS 1536 - 1976 Specification for centrifugal cast (Spun) iron pressure pipes for water, gas and sewage.
 - b. IS 1538 - 1976 (Part V) Specification for cast iron fittings for pressure pipes.

Wherever reference is made for Indian Standard Specification the latest specification is applied.

2. All cast iron pipes supplied shall confirm to class LA of Indian Standard specifications.
 - a. The work test pressure and the hydrostatic test pressure shall be as follows:
 - b. Hydrostatic Test pressure at works 3.5 N/mm^2 (35 kg/sq.cm.)

Hydrostatic test pressure after installation 1.2 N/mm^2 (12 kg/sq.cm.) All pipes to be supplied in this contract shall have SBR quality rubber gaskets rubber tyton joints as per BIS 5282, 12820 with the spigot end suitably chamfered for smooth entry of pipe in the socket fitted with SBR quality rubber gasket. Care shall be taken to ensure that fittings fit easily into this pipe.

c. Each pipe shall be coated in accordance to Indian Standard specification. All pipe shall be marked as under:

- Manufacturer's name or identification mark
- The Nominal DIA
- Class Reference
- Mass of pipe
- The number of this Indian Standard and
- The last two digits of the year of manufacture.

Cast Iron fittings

All cast iron fittings supplied shall confirm to heavy class of I.S. 1538 PART 1 to 23. The work of Test pressure and Hydrostatic test pressure shall be as follow:

1. Test Pressure

- | | |
|---------------------|-------------------------------------|
| • 300 mm to 600 mm | 2.5 N/mm ² (25 kg/sq.cm) |
| • 600 mm to 1200 mm | 1.0 N/mm ² (10 kg/sq.cm) |

Where non-standard fittings are required in special locations, this shall be supplied of steel of minimum plate thickness of 6 mm and fabricated as per drawings and directions of Engineer. These mild steel fittings will be specially protected against corrosion with painting as shown on drawing.

All Standard fittings marked as under:

- a. Manufacturer's name or identification mark,
- b. The Nominal DIA,
- c. Class Reference,
- d. Mass of pipe,
- e. The Number of this Indian Standard, and
- f. The last two digits of the year of manufacturer.

2. Valve Bodies

a. Castings

The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surfaces of castings, which are not machined shall be smooth and shall be carefully fettled to remove all foundry irregularities.

b. Forgings

All major stress bearing forgings shall be made to a standard specification, which shall be submitted if required to the Engineer-in-charge for approval before work is commenced. Forging shall be subjected to non-destructive tests to detect flaws if any. Forging shall be heat treated for the relief of residual stresses. The name of the maker and particulars of the heat treatment proposed for such forging shall be submitted to the MCGM. The Executive Engineer-in-charge or his inspector may inspect such forging at the place of manufacture with a representative of the Contractor.

c. Workmanship

Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice.

All similar items of the valve and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit in place of all similar items.

All parts, which can be worn or damaged by dust shall be totally enclosed in dust proof housings.

Protective coating shall comply with BS 1218 Clause 16, for use in tropics, or BIS 2906, Clause 7.

3. Spindle Details

The spindles shall be of Bronze and to permit the solid wedge gate to be so raised as to permit an unimpeded flow passage through the valve in open position. Where hand wheels are provided the direction of rotation and the words 'OPEN' shall be marked prominently on the upper side. All spindles contacting surfaces in the valve body shall be bushed with gunmetal.

4. Valve Gates

Each face of the gate shall be lined with heavy gunmetal rings, which will match with corresponding rings in the body. The rings shall be force fitted by special fixtures and riveted in the case of valves in the size range 450 mm and larger. When finally assembled, the body and wedge faces shall provide a watertight bearing surface. When shut, the gates shall ride on the body seats, to allow for wear.

5. Operation

The tops of the spindles or gears operated with extension spindles or tee keys shall be provided with caps of dimensions conforming to BIS 2906 Table III. The direction of opening shall be indicated on the caps.

6. Lubrication

At the points where lubrication is needed the Contractor shall furnish full details of the method to be employed. The requirement of the requisite lubricating equipment and lubricants for commissioning and operating and maintaining the valves for one year shall be furnished by the contractor.

7. Spare Parts

One spare spindle and nut shall be supplied under this contract for each group of 10 sluice valves or less of the different sizes. The contractor shall take this into account while quoting the rates for individual items. No separate payment shall be made for this work. In addition the Contractor shall submit a list of recommended spares for 5 years of operation and maintenance of all mechanical, electrical and instrumentation works covered under this contract. Spares supplied shall be new, unused and interchangeable with the corresponding components they are intended to replace.

8. Flanges

Valves of sizes from 80 mm to 300 mm shall have flat flanges as per BIS: 1538 Part IV Table I. Valves of sizes from 350 mm and larger shall have raised flanges as per BIS: 4504, Table 10/11 for 10 bar valves. The flange to flange distances shall be as per BIS: 780 for 80 mm - 300 mm valves and BIS : 2906 for 350 mm and larger valves.

9. Jointing Materials

Each valve shall be supplied under this Contract, with all-requisite joint rings, nuts, bolts and washers for making the joints on all the valves to be installed under this Contract. Jointing material between the connecting flanges shall conform to the requirements of BIS 638- 1965. Unless otherwise specified bolting used for jointing exposed connections shall be carbon steel, conforming to BIS 210 Grade 20 Grade B, with galvanized finish. Bolting for buried joints and joints that could come into contact with raw sewage shall be Stainless Steel, as per Clause 2.02 A3. Bolt holes shall be off centre and in correct adjustment longitudinally.

10. Factory Tests

All the valves shall be tested at the factory for smooth, trouble free operation and operating torque requirements by operating between fully open and fully closed position three times.

The hydrostatic tests shall consists of -

- a. Application of a pressure equal to 1 and a half times the maximum working pressure specified in this section with both ends closed and valve fully open, for ten minutes. No leakage of water should occur through the metal, flanged joints or valve packing gland, nor should any permanent deformation of any part occur.
- b. The pressure shall then be reduced to the working pressure and the wedge gate lowered, thus closing the valve. The stipulated pressures shall then be maintained for 5 minutes on each side in turn during which no leakage should occur on the downstream side of the valve seating.

11. Valve Operation

The sluice valve shall be operated by an electro-mechanical actuator, comprising of motorized gear train and screw assembly, which drives the valve stem. The actuator shall be supplied with the following accessories.

- a. AC electric motor,
- b. Reduction gear unit,
- c. Torque switch mechanism complete with set of torque switches,
- d. Limit switch mechanism complete with set of limit switches,
- e. Handwheel for manual operation,
- f. Hand-auto changeover lever with suitable locking arrangement,
- g. Local control switch / push buttons, and
- h. 415 V / 240 V AC control transformer

The actuator shall be suitable for operation in the climate conditions and power supply conditions given in the specification. The actuator shall be capable of producing not less than 1½ time the maximum required torque and shall be suitable for at least 15 minutes continuous operation.

12. AC Electric Motor

Each motor shall be fully tropicalised and suitable for operation in the prevailing climate conditions. They shall also be suitable for operating satisfactorily under variations of electric supply specified.

13. Motors

The electric motors shall be of 3 phase, squirrel cage type as per IS 325 with insulation to IS 1271 class "B". The winding shall be impregnated to render them non-hydroscopic and oil resistant. All internal metal parts shall be painted. The motor shall be rated for 30 min.

14. Motor Protection

The motor shall be protected by bimetallic over load relay. The relay shall be manually re-set type.

15. Motor Controls

The reversing contactor starter and local controls shall be integral with the valve actuator. The starters shall comprise mechanically and electrical interlocked reversing contactor of appropriate rating fed from a 220 V control transformer. 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:

- a. Local control only,
- b. Remote control plus local stop only,

c. 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.

16. Wiring and Terminals

Internal wiring shall be of grade PVC insulated stranded cable of 650 V and of minimum 1.5 sq.mm copper for control circuits and of minimum 4 sq.mm 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 PVC SWA PVC cables.

17. Enclosure

The actuator enclosure shall be IP 67.

18. Reduction Gear Unit

Reduction gear unit shall be of the totally enclosed oil bath lubricated type. The gearbox 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 valves under full indicated maximum operating pressure differential at a speed sufficient to cover the full extent of travel.

The valve operating equipment shall have a hammer-blow device to loosen stuck valve or retrieve jammed valve 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 valve torque.

19. Torque Switch Mechanism

The torque switch mechanism shall function as follows to stop the motor on closing or opening of the valve, upon actuation by the torque when the valve disc is restricted in its attempt to open or close.

The torque switch in the closing direction shall interrupt the control circuit if mechanical overload occurs during the closing cycle or when the valve is fully closed. The torque switch in the opening direction shall interrupt the control circuit if mechanical overload occurs during opening cycle or when the value is fully open.

The mechanism shall facilitate adjustment of the torque at which the switches are required to operate.

20. Limit Switch Mechanism

Non-adjustable limit switches shall stop the motor and give indication when the wedge has attained the fully open or closed position.

The adjustable limit switches shall function to actuate relays / switches, provided for system interlock, at the desired valve position in both the opening and closing directions.

21. Handwheel

A handwheel shall be provided for emergency operation. The handwheel drive shall be mechanically independent of the motor drive and any gearing should be such as to permit emergency manual operation in a reasonable time.

Check Valves

22. Cast Iron Check Valves

60 mm to 350 mm diameter valves shall be swing check- valves of the lever and spring type, flanged, and shall have cast iron body and renewable bronze seat, bronze hinge, stainless steel hinge shaft. The valve shall conform to I.S. 5312 and, where any of the requirements specified are not covered therein, to U.S. Federal Specification WW-V-51 D, Type IV, Class A.

Cast Iron shall conform to ASTM A-126-66 and flanges to ANSI B 16.1. The valves shall be designed for low head loss, shall be adjustable for non-slammimg closure and shall be seat-tight. An arrow showing direction of flow shall be prominently cast on body of valve. The water working pressure shall be 10 kg/cm square except that the valve shall have pressure rating same as the piping where the pipe class is higher. Valves shall be from approved manufacturer only.

2.30 Ductile Iron Pipes and Fittings

Pipes and Fittings

All pipes rubber rings and fittings shall be ISI marked.

a. General

Ductile iron pressure pipes and fittings shall be Class K9 unless otherwise shown on the drawings and shall comply with IS 8329 and IS 9523. All fittings shall be socketed unless specified otherwise.

b. Materials

The materials used in the manufacture of pipes and fittings shall comply with IS 8329 and IS 9523.

c. Tests

Tests on pipes and fittings shall be carried out in accordance with IS 8329 and IS 9523.

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.

2.31 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.

b. Flanged Joints

These shall comply with dimensions and drilling details in IS 8329 for PN 10 flanges. All flanged joints between steel and ductile iron pipework shall be electrically isolated joints. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All materials shall be supplied by a specialist manufacturer and be to the approval of the Employer's Representative.

2.31.1.1 Cement Mortar Lining

All pipes and fittings shall be internally lined with cement mortar in accordance with ISO 4179/IS: 11906. Cement mortar lining shall be applied at the factory in conformance with the above mentioned standards. No admixtures in the mortar shall be used without the approval of the Employer's Representative.

Pipe linings shall be inspected on site and any damage or defective areas shall be made good to the satisfaction of the Employer's Representative.

Lining shall be uniform in thickness all along the pipe. The minimum thickness of factory applied cement mortar lining shall be 3 mm for DN 300 mm pipe ; 5 mm for DN 350 to 600 mm pipe ; and 6mm for DN 800 mm pipes.

2.31.1.2 Coatings

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. Coating shall not be applied to pipe and fittings unless its surface is clean, dry and free from rust. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the 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/m² as described in Clause 5.2 of ISO 8179.

c. Bitumen Coating

Bitumen coating shall be of normal thickness 75 microns unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

d. Polythene Sleeving

Where polythene sleeving is specified to be applied in addition to bitumen coating it shall comply with ISO 8180. Site applied sleeving shall be stored under cover, out of direct sunlight, and its exposure to sunlight shall be kept to a minimum. Pipes having a factory applied sleeving must be stored in the same conditions. Joints in the sleeving shall be properly overlapped and taped in accordance with Manufacturer's instructions to provide in continuous sleeving.

e. Epoxy painting

Unless otherwise specified, pipes and fittings above ground level shall be epoxy painted.

All exposed pipes and fittings shall be painted externally with zinc rich epoxy primer and epoxy paint. Both shop and site application is to be done by airless spray equipment. Paints of reputed make and approved by Employer's Representative shall be used. Thinning or heating of paints will not be permitted except with specific approval from Employer's Representative and in accordance with manufacturer's instructions.

Each lot of primer and paint used by Contractor shall be accompanied by certified copies of the test results on hardness, impact and heat resistance and resistance to corrosion carried out by manufacturers in accordance with relevant Indian or International standards.

Surface preparation shall be in accordance with manufacturer's instructions, but as a minimum the pipes shall be abrasive blast cleaned to BS 7079 Grade Sa 2.5 or equivalent to achieve surface roughness profile of 40 – 50 microns. The primer shall be applied within 2 hours of surface preparation, before flash rusting can occur. Two coats of Zinc rich epoxy primer shall be applied by spray equipment on the pipes and fittings.

The priming coat shall be uniform in thickness and free from floods, runs, sags, drips, and bare spots. Any bare spots or defects shall be recoated with an additional application of the primer. All defects shall be rectified as per the instructions of the Employer's Representative.

Though the priming coats become touch dry in 10 to 15 minutes, the finishing coats with epoxy paints shall be applied after allowing the film to cure at least for 48 hours. The final dry film thickness shall be a minimum of 300 microns. This may be achieved by applying in 2 to 4 coats.

On completion of the work, the contractor shall remove any oil stains or paint spots, leaving the pipes and fittings in a clean and acceptable condition.

3 PARTICULAR TECHNICAL SPECIFICATIONS FOR MECHANICAL WORKS

With reference to the scope of work for Mechanical items given in Chapter 1 of this Section 2C and in Section 2A of these Tender Documents, the Technical Specifications are given below. The Mechanical works are to be carried out with reference to the design and technical specifications provided. The Contractor should prepare his technical bid and estimate his cost for mechanical works with reference to the designed values and technical specifications of various items given below. For mechanical equipment specifications data sheet is given in Section 11. Contractor is required to fill the data sheets.

3.1 Bar Screens with Continuous Raking type Mechanical Screen cleaning mechanism:

Contractor's scope under this component includes design, manufacture, Supply, inspection at vendor's works, installation, erection, testing & commissioning of Bar screens with continuous front / back-raking type electrically driven / hydraulically operated mechanical screen cleaning mechanism. The scope also includes provision / supply of spares required for bar screen and screen cleaning mechanism for the entire duration of the Contract.

The screen bars shall be spanning as a single piece from bottom to top of the screen / upto 27.5m THD and shall be designed to withstand the operation of raking mechanism, impact of floating and suspended materials, flow and water level during the pumping / non pumping operation. The screen panel assemblies and bars shall be structurally designed for a head of water equal to their height assuming the screen panel to be fully blinded.

Screen cleaning mechanism shall be multi-rake type designed to continuously clean the bar screens and each rake shall be able to clean the entire screen front area from about 21.0 m THD to 27.5 m THD within a period not exceeding 20 seconds.

The screens shall be installed between 78-85 degrees to horizontal and shall be designed to facilitate positive front or back raking arrangement. In case of multiple screens or multiple panels, each screen or panel shall be of the same size and the width of each screen panel shall not exceed 4 metres. Width of screen cleaning mechanism shall cover the entire width of each screen panel.

The Contractor is required to provide appropriate design of Bar screens which are suitable for installation within the watercourse of the nalla and will generally arrest all floating materials, suspended materials, plastics, bottles, rags, tree branches, debris, solid waste, dead animal bodies etc. having dimensions greater than 40mm from reaching the pump bays during continuous storm water pumping operation. The Contractor shall take in to consideration the following factors while selecting the Material of Construction and designing the bar screens and Mechanical screen cleaning mechanism and offer the most suitable, functionally appropriate and robust design of Bar screens and the mechanical screen cleaning mechanism:-

1. The material of construction for Storm water - that besides rainwater runoff will include sewage, effluent, brackish water and sea water - shall be minimum stainless steel 316L for the screen bars, rake, tines, dead plate and frame.
2. The storm water will contain floating materials, suspended materials, sewage, effluent, plastic, bottles, rags, tree branches, debris, silt, sand, other deposits / solid waste, dead animal bodies etc.
3. The components of screen bars and the screen cleaning mechanism / arrangement will be subject to alternate drying and wetting during the course of operation.
4. The screen bars and the screen cleaning mechanism shall be designed for continuous duty. The individual screens will be subject to continuous flow of about 9 m³/sec during pumping operation.
5. The Mechanical Screen design shall be rake type with conveyer system. The screen operating mechanism shall be automatic. The speed of the screen cleaning rake shall be at least 20 m/min. The operating mechanism shall be designed such that every screen can be independently operated.
6. The Mechanical Screens shall be designed considering highest tide levels.
7. Screen Mechanism: Screen bar assembly shall be fitted across the screen chamber. Screen shall have a series of vertically oriented bars spanning the inlet channel width and spaced as specified. Bars shall be sufficiently rigid to prevent vibrations in stream wise and lateral modes and to withstand the maximum differential head that will occur with the screen totally blinded. Bars shall have tapered cross section with minimum 8 mm thickness facing Stormwater to prevent jamming of screenings between bars. Bars shall have supports only at both ends. Bar geometry, dimensions and thickness shall be as per Manufacturer's design and the thickness of bars shall be enough to sustain the load of the screenings and the hydraulic flow.
8. Rake carriage: The rake carriage shall comprise a stiffened framework to which is attached replaceable rake tines. The rake tines shall be suitable to accommodate bulky screenings. Rake carriage shall incorporate suitable devices to enable the rake to ride over any small obstacles wedged in the screen and automatically stop the drive motor in the event of the rake jamming against a large obstruction. There shall not be any mechanical damage resulting from obstruction wedged in the screen bars. The rake carriage shall always come to rest in a parked position with the rake above the stormwater level.
9. Rake Lifting Mechanism: Lifting mechanism shall consist of a SS 316 sprocket and endless chain.
10. Dead plate: Stainless Steel SS 316 dead plate extending from the top of the bars to the deck level shall be provided to ensure that screenings do not fall back. Dead plate shall be made of minimum 5 mm thick plate. The clearance between the tines and the dead plate shall not exceed 5 mm.
11. Automatic Screen Clearing and Screenings Removal: The screen shall be provided with the necessary controls and sensors to anticipate blinding of the screen, and automatically clear the screen and remove the accumulated screenings from the screen surface.

- a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes for interval between two operations.
 - b) In addition, operation shall also be carried out alternatively through differential level across the screen
 - c) Control system for the conveyor shall be designed to achieve the following:
 - a) Conveyor shall be started when any of the rakes starts its upward travel.
 - b) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.
 - c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and conveyor belt, operation of stop push button, and overload prevention for screen and belt conveyor shall be included in the control scheme.
12. Operation of the screen: The raking tines engaging into the static screen flats shall be minimum 60mm long in case of front rake and 350mm long protruding from static flats in case of back raking screens. Tines shall be mounted on horizontal raking tine beam (of minimum 350mm width) which travels upward making 90 deg. to the static screen flats. The raking tines should insert under the silt / other waste material at the base of the screen and lift upwards all the debris and floating material over the total width of the screen in one continuous movement. All electrical motors of mechanical screen installation shall be of suitable capacities & shall be operated on 440V AC electric supply with voltage variation of \pm 10% and frequency 50 Hz with variation of \pm 5%. Motors shall be of squirrel cage induction type conforming to IS 325. Motors shall have protection class IP 66 and shall have F class insulation. Motors' duty type shall be selected suitably. Protection against overheating and overload conditions shall be provided for all the motors. Embedded thermostat can be used in stator winding for protection against overheating. Suitable provision shall be made to bypass the screen by lifting the same upto the highest tide level in case of emergency such as flooding or blocking of the screen situation or as & when required.

Screenings Conveyor System: For the disposal of screenings, a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads. The conveyor belt and chute shall be properly enclosed by dog box type hood in FRP construction to avoid flying of screenings due to wind. The hood shall be provided with inspection covers.

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

The belt material shall be two ply nylon or equivalent with minimum 6 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close-fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length center tube journaled concentricity. The outer shell, centre tube and precision

die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.

The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.

Shafting for pulleys shall be of heat-treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.

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

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

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

Screenings discharge chutes shall be provided to transfer screenings from the screens to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials.

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

13. Waste collection & transportation: The contractor shall also provide adequate number of covered refuse collection bins with input window of required size for collection and disposal of removed screenings. In addition to mechanical raking, manual efforts required if any for removal, collection, cleaning of screen face and shifting of removed screenings to the common disposal point shall be deployed by the Contractor on his own at no extra cost to MCGM during commissioning as well as during entire operation and maintenance period. All the removed screenings shall be transported by the Contractor as per MCGM's debris management plan to the designated location as directed by the Engineer for disposal. No separate payments will be made.

Control panel for Screens

The Control panel provided shall be suitable for 415 V, 3 phase, 50 Hz electric supply to operate the entire back raking system. It shall house main switch, fuses, and contactors, PLC, differential level switch at upstream & downstream of the screen for differential level measurement. Operating (push) Buttons shall be provided for operation. Control lights shall be provided for indication purpose. The entire operation of screens shall be automated using PLCs. Cabinet equipped with electronic equipment for detecting the level differential, including radar scan detection equipment installed up-streams and below stream of each screen. The screens shall be operated by pre-setting of the required level differential (150 mm). The screens shall also be operated automatically with PLC & differential level measurement, manually and with time indication. The panel shall be waterproof, dust and vermin proof. The cables required for the entire system shall be of suitable ratings. L.T. switchgear and all electrical components shall be of approved makes as per Section 2D, Volume 2 of this Tender document.

It is contractor's responsibility to generally ensure that the screen panels are not blocked during any of the pumping operations and the screen area in front of screen panels is kept free from deposits including sand, silt, plastics, gunny bags, tarpaulin, tree branches, logs, mattresses, dead bodies etc. thereby ensuring that the storm water flow reaches smoothly to the pumps. The Contractor shall also take all safety precautions in carrying out above operation.

The screens shall be easily removable and replaceable in their position. The screen parts and assemblies shall be easily accessible from all sides for cleaning as well as for any attendance during maintenance requirements.

Moving parts and rotating parts of the screen assemblies which are partly or fully suspended in water during operation cycle shall be of permanently lubricated type. The design shall ensure that the functioning of moving / rotating parts of screen/screen cleaning equipment are not jammed or affected due to presence of silt, debris, plastic bags etc.

Fabrication of screens to be such that bolts, cross bars / stiffeners will not interfere with raking operations.

Screens shall be installed parallel to each other in screen channels.

The contractor shall also provide adequate number of refuse collection bins of required size for collection and disposal of removed screenings. The arrangement shall include belt conveyor. Belt conveyor shall cater to the screenings from all the installed screens and shall discharge into the refuse collection bins via a chute. In addition to mechanical raking, manual efforts required if any for removal, collection, cleaning of screen face and shifting of removed screenings to the common disposal point shall be deployed by the Contractor on his own at no extra cost to MCGM during commissioning as well as during entire operation and maintenance period. All the removed screenings shall be transported by the Contractor as per MCGM's debris management plan to the designated location as directed by the Engineer for disposal. No separate payments will be made.

The Contractor shall submit complete details of design, technical data sheets, drawings including layout and general arrangement drawings of the screens and

screening system selected by them including list of successful installations carried out by the manufacturer along with their technical bid to MCGM for review and evaluation purpose. These details shall also be submitted during detailed engineering stage by the Contractor for approval of the Engineer.

All drives including motors, gear boxes, chains etc. used for mechanical screen cleaning and conveying arrangement shall be of heavy-duty type suitable for outdoor installation in corrosive environment and continuous duty.

The entire screening and screenings conveying area shall have safety provisions like hand-rails, toe guards, chain covers, drive covers etc.

3.2 Trash Racks

The scope of supply shall include Trash rack system with all accessories and appurtenances, including, but not limited to:

- Removable L-type Trash racks which are installed by lowering the same inside guide channels or grooves provided in the trash rack channel so that the trash racks may be readily removed by lifting them through guides.
- Lifting Arrangement by Travelling Hoist/ EOT;
- Rakes for manual cleaning after bringing them on cleaning area.

General

Two trash racks will be installed in series, with one working and one stand-by per channel. The structural arrangement of racks generally consists of equally spaced trash rack vertical bars supported on horizontal members connected to end vertical members, which sit in the grooves of guide rail. The trash rack will have L-type structure at the lower end for support and for collection of screened material which will extend for minimum 600 mm from vertical bars. Hook will be provided at the upper end for lifting of the Trash Rack by Hoist. The minimum thickness of the bars will 12 mm with minimum width of 80 mm. it should preferably be fabricated from flats with rounded edges. A platform at suitable/finished ground level shall be provided to manually clean the trash rack by raking and by water jetting arrangements for collection of screenings in portable screenings container.

• Aperture Size

The screen apertures shall be sized to capture particles down to 100 mm size. The clear spacing between the bars will be 100mm

• Inclination of Trash Racks

Racks will be installed on guide rails which will be kept in vertical position at 90 degrees.

• Velocity through racks

Velocity up to 1.2 m/s at peak flow and 0.6 m/s at average flow on the gross area of racks may be permitted.

- **Required Downstream Water Level**

Contractors should state the maximum and/or minimum allowable water levels downstream of the screen in order to pass the required flow.

- **Guaranteed Flow Rate and Head Loss**

The loss of head should be calculated from the following formula:

$$\text{Head loss} = KV^2 / 2g$$

Where K = trash rack loss coefficient ($1.45 - 0.45 R - R^2$);

R = net area through the rack bars gross area of the racks and supports

V = velocity of flow through trash rack, computed on gross area, and

g = acceleration due to gravity.

Allowance should also be made for partial clogging of racks with trash to 50 percent of area of racks may get obstructed in practical operation.

The trash rack shall effectively screen all flows up to the design flow. The Contractor shall guarantee the following screen performance parameters:

- Clean water flow rate capacity (l/s) at the maximum allowable water depth downstream of the screen
- Clean water head loss at the max flow rate and maximum allowable water depth downstream of the screen
- Maximum sewage flow rate capacity (l/s) at the maximum allowable water depth downstream of the screen based on their expected screen blinding in sewage

Material of Construction

The material of construction of the trash rack equipment shall be in grade 316L stainless steel.

Manual Raking and Screenings Removal

Suitable arrangement should be made for cleaning the racks manually at regular intervals after removing the trash rack installed in channel through guide rail. The frequency of cleaning of the racks would depend upon the rate of accumulation of trash. Not more than 33 percent of the trash rack area should be allowed to clog the racks at any time. The raked screenings will be collected in portable screenings container

Portable Screenings Container

Portable screenings containers made of galvanised steel shall be provided to store the screenings until time of pick up. The container shall have capacity of approximate 5 m³ and shall be of a convenient height to permit the discharge of screenings directly into the container. The containers shall have hinged covers and their design shall permit them being lifted by an overhead hoist or packer truck. The container will have four

wheels each of about 20 cm diameter and two of which shall be swivel castors. The maximum height of container including wheels shall be 1m. The sides shall be constructed of 12 gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50mm x 50mm x 5mm angle iron.

Structural Requirements

Structural connections in the trash rack should be designed and provided for the failure load of the structural members. All flats should be welded to the intermediate horizontal members and the top and bottom horizontal members for better resistance to vibrations and to avoid stress concentration at the external edge of the groove. The vertical member of the trash rack should be so arranged as to apply the load near the inner part of the rack guide. The guides of the trash racks should be so proportioned that the side members get lateral support from guides after deflection to take up the clearance in the slots.

Access

Safe access shall be provided to all trash racks when hoisted to allow for cleaning, inspection and maintenance activities.

Corrosion Resistance

All metal parts of the screen equipment that are in contact with the sewage shall be constructed of a suitable grade of corrosion resistant stainless steel 316 L.

Design Life

The design life of major components shall be thirty years.

a) Installation

It is the Contractor's responsibility to install the trash rack system correctly and achieve the required operation. The Contractor shall provide a representative who has knowledge and experience in the proper installation, start-up and operation of the screen equipment to inspect the final installation and supervise the commissioning tests.

b) Tests on Completion

When the Plant has been installed on site and is ready for energizing, the Contractor shall notify the Engineer-in-Charge in writing that Tests on Completion are about to commence. At least three days' notice shall be given. The Engineer-in-Charge and/or his Representative may attend the tests at his discretion.

c) Commissioning Tests

The Contractor's representative shall subject the screen to the following tests. The tests shall include, but not be limited to:

- Checking alignment of all components and adjust if necessary;
- Checking that all equipment, safety devices and equipment protection devices function properly;
- Examining protective coatings and repair as necessary;

- Installing equipment for an appropriate time and check for correct operation
- Checking the operation of all equipment under field control
- Demonstrating extraction of installed trash rack through guide rails by hoist for cleaning
- All necessary corrections and adjustments made shall be recorded. A written report shall be provided by the Contractor's representative at the completion of the tests, certifying that the equipment has been properly installed and operates satisfactorily all test records are to be appended.

- **Reliability Tests**

Reliability testing will not be commenced until the Tests on Completion have been completed and approved by the Engineer-in-Charge.

The Plant shall be required to operate under the normal operating conditions within the limits of performance offered by the Contractor, and their continuous or intermittent performance as may be more convenient for the operation of the works. The Plant shall operate without failure of any kind for period of one calendar month.

Should any failure (other than that of an entirely minor nature) occur in any portion of the Plant, due to or arising from faulty design, materials or workmanship or staff training (but not otherwise) sufficient to prevent commercial use of the plant, the test shall be deemed to have failed. The test period of one month will recommence after the Contractor has remedied the cause of the failure. The onus of proving that any failure is not due to faulty design, materials, workmanship or training will lie with the Contractor.

In cases where the responsibility for failure cannot be determined initially, the Contractor is to attend to such failures as though they were his responsibility.

- **Relevant Standards**

The design, manufacture, supply, storage of all equipment shall comply with all Indian Standards, (or in the absence of Indian Standards, the appropriate International Standards) Acts and Regulations in their latest amendment, including local statutes covering:

- Health and Safety
- Dangerous Goods
- Factories and Commercial Premises
- Buildings
- Electricity Regulations and Codes of Practice

The Standards referred shall form part of this Contract. Other Standards, Codes of Practice and Regulations not referred to, but which would be applicable to the design, manufacture, installation, testing or commissioning of the equipment under this contract shall be deemed part of the Contract.

- **Working Stress and Design**

The design of all parts shall ensure that under the most onerous of conditions they will not be damaged or corroded.

Any joint that will need to be dismantled during maintenance shall be made by anti-corrosion type fasteners.

All spare parts shall be fully interchangeable with the original part. If the spare part is unavailable due to cease of production, the Contractor shall give notice to the Employer in writing, detailing the options available to the Contractor.

All parts shall be designed to minimise the risk of fire and consequential damage. All parts shall be designed to prevent the ingress of vermin, dust and dirt. All electrically live or moving parts shall be adequately guarded to prevent accidental contact

3.3 Stop logs

In addition to the above, the Contractor is also required to provide required quantity of stop logs at upstream and downstream of screens as well as tidal control gates. These Stop logs will be provided to cover entire width of the bay/channel and maximum depth of water including free board for isolating the respective equipment during non-monsoon period and to facilitate maintenance of the screens and / or tidal control gates. Stoplogs shall be provided in two widths to provide different depth combinations or shall be constructed as a single panel covering the width of the channel and the depth of water upstream of the log. Each log shall have two equally spaced stainless steel lifting lugs. Provision for installing one set of stop logs each, covering the entire width at the upstream and downstream of Screens and/or Tidal Control Gates for one Screen and/or Tidal Control Gate at any given instance, shall be made by the Contractor. Necessary frame / guide arrangement for these logs shall be installed upstream and downstream of all installed Screens and Tidal Control Gates. Storage racks for storing the set of stop logs shall also be provided near the Screens and Tidal Control Gates. Size of all stop logs should be identical for ease of use. Equivalent or superior technology for sealing between logs and frame is acceptable.

3.4 Roller Gates

Design, manufacture, Supply, inspection at vendor's works, installation, erection, testing & commissioning of Roller Gates and supply of necessary spare parts.

Roller gates shall be provided to isolate each of the pump bays whilst maintaining flow to all or any of the others.

General

The gate leaf shall have an opening perforated through front and rear surfaces of the gate leaf; a pair of rollers arranged along both lateral sides of the gate leaf and adapted to be seated in guide paths defined in guides of the guide frame when the gate leaf is lowered to keep the gate in a closed state, so as to prevent vibrations of the gate leaf and leakage during operation.

The arrangement of constituent members of the gate leaf and the positions of connecting spindles of the actuator unit connected to the gate leaf are set to allow the

centers of gravity of the gate leaf equipped with pump(s) to keep a balance at the connecting spindles of the actuator.

The gate leaf and the arrangement of constituent load bearing members shall be arranged in order to prevent the resonance vibration, which may occur when the natural frequency of gate are placed within 80% ~ 120% of submersible pump's frequency, during the operation of the submersible pump selected under this specification

The skin plate on opposite side of water flow direction shall be supported and reinforced with the upper and lower horizontal beams, vertical beams and both sides end beams. The shape of the above beams shall have reinforcing ribs in order to sufficiently sustain the applied design loads to the gate leaf and to keep horizontal deflection of horizontal and vertical beams within 1/1000.

The thickness of major members for roller gate and flap gate shall be inclusive of corrosion allowance thickness of 1mm for carbon steel and none for stainless steel per each water interface in addition to the calculated minimum thickness of members.

The roller gate, flap gate, stop log shall also have perimeter sealing rubber forming a rectangle at one side of gate leaf facing the downstream side of which shape will be "P type" or "Y type" and shall be provided with seals such that the sealing surfaces are reasonable watertight all around.

The gate leaf shall be designed that when the upstream water is forcibly discharged by operation of the pump(s) in a closed state of the gate, it shall be designed to prevent vibrations and noises caused by a rotating of the pump by resulting from tight engagement of the main rollers on gate leaf and the wedges on guide frame.

GUIDE FRAME FOR ROLLER GATE, FLAP GATE AND STOP LOG

The guide frame for gate leaf shall be designed to withstand the design loads as well as transfer the dead load and the dynamic load generated while operation of the system.

The guide frame for gate leaf shall provide the tight sealing device so as not to allow the leakage as stated in IS 13349 for Class 1 sluice gates.

The shape and dimension of guide frame shall be suitable for easy operation, watertight of the respective gate leaf.

The guide frame shall be designed in consideration of constructability and operation and maintenance of the respective gate leaf.

The material of guide frame on which sealing rubbers meet shall be of stainless steel STS316L and the supporting structural steel which will be embedded into the concrete shall be of structural steel SS304.

As the guide frame being an integral part of the gate structure, the guide frame shall be designed and erected to prevent movement and deflection from concrete work.

ROLLERS FOR GATE

The material of main roller shall be forged steel or approved material of equivalent or more. The bearing to be used for roller shall be of lubrication free OILLESS bearing.

Bearing load of main roller should not exceed 0.8 times the rated bearing allowable load.

The journal surface of the shaft of main roller should be eccentric with respect to the shaft end so that the track of all the rollers can be adjusted. The trajectory of the change should be adjusted so that all the wheels make uniform contact with the track frame

The diameter and width of the main roller shall be of sufficient strength taking into consideration of the contact between the roller and guide frame. The contact stress between main roller surface and the guide frame shall be within the allowable value.

The diameter of main roller shall be planned to withstand the designed load conditions thereof.

In considering the hardness of the contact surface, the material should be forged steel, roller rail should be harder than roller, and shaft should be harder than bearing.

In order to prevent resonance, the stiffness of the roller type gate should be given in design thereof. The manufacturer should submit the satisfactorily results on this during approval stage of design documents.

The main rollers are formed on the upper and lower sides of both sides of the gate leaf, and the main rollers are seated on the guide frame when the gate leaf is closed, so that guide grooves are formed to prevent vibration generated when operating the pump(s). It should be made so that it absorbs vibration between gate leaf and guide frame.

As the guide frame is integrated with the gate structure, and the permissible residual unbalance (vibration) from the pump(s) should be transmitted to the structure evenly through the guide frame.

GATE SEALS

A. Gates shall be provided with seals at the downstream of gate such that openings are watertight against downstream direction for all water levels and the leakage at the maximum differential head shall not exceed 0.1 litres per hour per gate leaf.

B. The seal shall have sufficient strength to withstand any shearing effect during the lifting operations. Test certificate for the rubber seals on its properties and strength shall be made available in the final report.

C. The rubber seals for the sides and top of the gate shall be the solid "P" type. The seal for the bottom of the gate shall be the flat rubber type for smooth operation of the gate. Seal mounting shall be done under the utmost care to prevent damage to the rubber under all conditions of operation. The side seals shall be adjusted for light contact against the sealing surface on the side rail assembly with no water load on the gate. A sufficient support shall be provided for the seal to eliminate possibility of water pressure bending it open.

D. The seal shall be moulded from the rubber containing not less than one percent by weight of copper inhibitor or equivalent, and shall have the following physical properties:

Material	Neoprene 2
Shore A durometer hardness	40 ~ 80 (degree)
Minimum elongation	450 %
Minimum tensile strength	14.5 MPa
Maximum water absorption	5% (by weight)
Specific weight	1.1 ~ 1.4

Transitions from side seals to bottom seal, if used, shall be made with moulded corner pieces spliced to the main seal pieces at about 300 mm from the corner.

Gate seal fastenings and backing plates shall be stainless steel meeting applicable requirements of recognized standards.

The base seal may be combined with a buffer or bearing strip adequate to arrest the travel of the gate when it is being lowered and to carry the weight of the gate and allow for the deformation of the gate when it is subsequently subjected to hydraulic loading in either direction.

Gate seals and their fixings shall be designed in such a way that seals are easily replaceable and adjustable.

Side seals shall be arranged so that water pressure increases the sealing effect.

Seals shall be manufactured from synthetic rubber having suitable physical and chemical properties and having good resistance to abrasion, temperature changes and alternate wetting and drying, by the water, strong sunlight, ultraviolet rays, oxidation and ozonisation.

3.5 Storm Water Submersible Pumps:

Design, manufacture, Supply, inspection at vendor's manufacturing place, installation, erection, testing & commissioning of Storm water Pumps and supply of necessary spare parts. The scope of work includes 7 numbers of pumps of 6cum/sec capacity each at minimum 6m head.

Individual pump shall be designed to deliver flow not less than 6 m³/sec when city side water level is not greater than 23 m THD and on seaside water level is 27.5m THD. The design of pumps should be such that combined flow of all 7 pumps when running simultaneously shall in no case be less than 42 m³/sec. while calculating the head over the pump the sum-total of following shall be considered and presented by the bidder in his technical proposal.

- Static head considering the water level on u/s side and d/s of pumps as stated above

- Head loss on suction side of the pump
- Head loss on discharge side of pump
- Head created due to thrust from seaside due to high tide of 5.2m

The pumps shall be robust in design capable of starting and stable operation at minimum permissible water level as guaranteed by the pump manufacturer and also when the u/s water level is 27.1 m THD. The pumps shall be capable of operating with the sump surcharged to its maximum level. The pump motors shall be rated to meet power requirement at both of these conditions. Each pump shall be designed to have a stable head Vs flow characteristic over the entire range of pumping operation and shall not deliver large changes in the discharge quantities with small changes in the differential head.

All the pumps shall be horizontal / vertical / inclined axial flow propeller type pumps driven by motor of suitable rating. The pumps shall be designed to satisfactorily handle solids of 100mm diameter incompressible solids and 200 mm size compressible solids while pumping the storm water.

The pumps shall be equipped with a electric motor of required kW rating mounted on the same shaft, connected for operation on 6.6 kV, 3 phase, 50 hertz power supply with heavy duty electric power cable of adequate length without any joints or JBs in between, sufficient for direct cabling between the pump motor and 6.6kV soft starters mounted in Electrical Panels room. Each pump shall deliver 6 cubic meter per second at design head at minimum pump efficiency of 80 %.

The pumps shall be operated as fixed speed units with the number of pumps operating being determined by the flow requirements necessary to maintain the inlet water level at or below 26.0m THD or as specified by MCGM. The Contractor shall determine the operating inlet control level range to ensure that the starting frequency does not exceed the drive motor rated starts per hour.

Each pump shall be provided with anti-cavitation device either in line with the pump or mounted at the pump bay near the pump suction to prevent cavitation/vortex formation.

The Bidder shall guarantee kW withdrawal from DG system, considering hydraulic load, pump efficiency and motor efficiency at duty point, namely, flow of 6 m³/s and head of 6.0 m. The Bidder shall test and establish this at site.

Further, the Bidder shall also work out, declare and guarantee maximum possible load in terms of kW under any hydraulic operating condition possible at site. The Bidder is advised to note the type of discharge condition for the pumps.

The pump motors and the DG sets shall be sized based on the maximum possible load as mentioned above and not necessarily on the duty point load basis.

The motor shall provide a margin of 10% over the maximum possible load at site under any operating condition and the DG sets shall provide a margin of 15% over the same maximum possible load condition.

The kW rating of pump motors and DG sets indicated in this specification, are indicative only and are minimum acceptable values. If the Bidder is required to provide pump motors of higher kW rating and hence DG sets of higher kW & kVA rating, he shall do so in his Bid. No commercial implications shall be raised by the bidder on this account and the same will not be accepted by the Buyer under any circumstances.

The Bidder shall note that he should be in a position to start and run all the 7 pumps simultaneously under maximum load condition (not necessarily duty point condition) on 4 nos. (min) DG sets, without any limitation on continuous basis without any interruption.

Individual pump shall be able to operate minimum 6 start-stops per hour.

Material of Construction

Pump components shall be subject to severe environmental conditions like exposure to marine environment, natural tides and wave action, exposure to brackish and saline water, alternate drying and wetting, abrasion due to floating and suspended material etc. the Contractor while designing the pumping system and selecting the material of construction of different components shall take into consideration the above factors.

Major pump body components and anti-cavitation cone shall be of (minimum) gray cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blowholes or other irregularities. All exposed nuts or bolts shall be 316 stainless steel. All metal surfaces coming into contact with the pump, other than stainless steel, shall be protected by a factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish coating on the exterior of the pump.

Sealing design shall incorporate metal-to-metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile rubber or Viton O-rings. Fittings will be the result of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit. Rectangular cross-sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal. No secondarily sealing compounds, elliptical O-rings, grease or other devices shall be used.

Cooling System

The pump motor shall be cooled by the passage of the pumped fluid, flowing during operation. The cooling system shall provide for continuous pump operation in liquid or ambient temperatures of up to 104°F (40°C) in accordance with NEMA standards. Operational restrictions limiting the liquid or ambient temperatures below 104°F are not acceptable.

Cable / Entry Seal

The power cable shall be sized in accordance with NEC and ICEA standards and shall be of sufficient length without the need of any splices.

The outer jacket of the cable shall be oil resistant chloroprene rubber. A wire armored vinyl tube shall be available, as an option, to encase and protect the outer cable jacket during operation in adverse pumping applications. The cable entry system shall

preclude specific torque requirements to insure a completely watertight and submersible seal. The system shall consist of dual cylindrical elastomer grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and entry inside diameter. The grommets, compressed by the cable entry unit, shall provide a strain relief function, separate from the function of sealing the cable. The assembly shall provide ease of changing the cable using the same entry seal.

The cable entry junction chamber and motor shall be separated by a terminal board, which shall isolate the interior from contaminants gaining entry through the pump top.

Motor

The pump motor shall be an induction type designed for 6.6kV, 3 Phase, 50 Hz power supply, NEMA B design with a squirrel cage rotor, housed in an air filled, watertight chamber. Oil filled motors shall not be considered acceptable. The stator windings and stator leads shall be insulated with moisture resistant Class "F" insulation rated for 155°C with temperature rise restricted to Class B (130 deg. C). The stator shall be dipped and baked three times in Class "F" varnish and shall be heat-shrink fitted into the stator housing. The use of bolts, pins or other fastening devices requiring penetration of the stator housing is not acceptable. The motor shall be designed for continuous duty handling pumped media of 104°F (40°C) and capable of up to six starts per hour. The motor horsepower shall be adequate so that the pump is non-overloading throughout the entire pump performance curve and as described below in details. The rotor bars and short circuit rings shall be made of copper. Thermal switches set to open at max. 130°C shall be embedded in the stator lead coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel through recommended monitoring unit. The motor and pump shall be designed and assembled by the same manufacturer.

The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15. As clarified under clause 3.4 above, the motor shall be sized based on the maximum possible operating load at site and not necessarily duty point load. Further, the motor continuous maximum rating shall provide a margin of 10% over this maximum possible load. Service factor of 1.15 specified is only an emergency provision and must not be consider while sizing (kW rating) of the pump motor for maximum possible load. The motor shall have voltage tolerance of plus or minus 10% and frequency tolerance of plus or minus 5 %. The motor shall be designed for operation up to 104° F (40° C) ambient temperature, with a temperature rise not to exceed 162°F (72° C). A performance chart shall be provided showing curves for torque, current, power factor, input/output kW and efficiency.

Bearings

The pump shaft shall rotate on two bearings. The upper bearing shall be a single ball type bearing to handle radial loads. The lower bearing shall be a double row angular contact ball bearing to compensate for axial thrust and radial forces. The minimum L₁₀ bearing life shall be 100,000 hours at any point along the usable portion of the pump curve at the maximum pump speed.

Mechanical Seal

Each pump shall be provided with a double shielded mechanical shaft seal system consisting of two seal sets, having spring connection. The seals shall operate in a lubricant reservoir that hydro dynamically lubricates the seal faces at a constant rate. The lower, primary seal unit, located in the lubricant chamber, shall contain one stationary and one positively driven rotating, silicon-carbide ring. The upper, secondary seal, located in the lubricant chamber and the motor housing, shall contain one stationary and one positively driven rotating, solid sintered tungsten-carbide seal ring. Each seal interface shall be held in contact by its own individual spring system. The seals shall require neither maintenance nor adjustment and shall be capable of operating in either clockwise or counterclockwise direction of rotation without damage or loss of seal. For special applications, other seal face materials shall be available. Equivalent or superior technology for seals is acceptable.

Each pump shall be provided with a lubricant chamber for the shaft sealing system. The lubricant chamber shall be designed to prevent overfilling and to provide lubricant expansion capacity. The drain and inspection plug, with positive anti-leak seal, shall be easily accessible from the outside. The seal system shall not rely upon the pumped media for lubrication. The motor shall be able to operate dry without damage while pumping under load. The seal lubricant shall be nontoxic.

Pump Shaft

The pump and motor shaft shall be the same unit. The pump shaft is an extension of the motor shaft. Couplings shall not be acceptable. The shaft shall be of stainless steel grade 410 or superior for handling storm water and pumping conditions as described on pg. 37 above.

Propeller

The propeller shall be of Duplex Stainless Steel for handling storm water and pumping conditions as described on pg. 37 above . Propeller shall be dynamically balanced, fixed pitch design. The propeller shall be keyed to the propeller hub and retained with one or two propeller bolt(s) and the propeller hub shall be keyed to the shaft by sunk key. A replaceable wear ring system shall be utilized to provide efficient sealing between the propeller and suction inlet casing. The wear ring shall be well machined grey cast iron.

Protection

The stator shall incorporate thermal switches in series to monitor the temperature of each phase winding.

Should an over temperature condition occur, the thermal switches shall signal the control to stop the motor and activate an alarm.

A sensor shall be provided to measure the lower and upper bearing temperature. In the event of a high bearing temperature, the sensor shall signal the control to shut down pump and activate an alarm.

A leakage sensor shall be installed in the lubricant chamber to detect seal leakage prior to entry and contamination of the lower bearing and motor stator housing.

Monitoring

The pump manufacturer shall provide, for each pump, a self-contained, solid state, microprocessor-based pump monitoring module to supplement the pump control system. The pump monitoring and protection unit module shall provide a single location within the control system for pump sensor output processing. The unit shall provide individual inputs, and alarm indication, for the thermal switches / sensors, leakage sensor(s) and bearing & winding temperature sensor(s). The system shall provide two digital displays and shall be capable of simultaneously indicating the stator and bearing temperature(s). An adjustment for the alarm indication values shall be provided. The unit shall be mounted in the control panel and outputs shall be given to pump HT / LT panels and PLC system for necessary controls.

Pump testing

All the pumps shall be tested at manufacturer's works prior to approval for dispatch. During testing of pumps, the performance of pumps shall be demonstrated for at least 5 differential heads including its duty point over range of suction levels in the pump bay from maximum level to be maintained in the nallah to minimum operating level defined by the manufacturer of the pump. The pump manufacturer should submit an undertaking for satisfactory performance of parallel operation of pumps. During the testing of the pumps described as above, at each test point i.e. differential head and flow, power and current consumption by the motor shall be measured and recorded and the readings will be cross verified with the pump characteristic curve submitted by the Manufacturer and approved by the Engineer.

In case the pump performance curve plotted during witness testing as manufacturer's works does not match with the approved pump characteristic curve, the pump will be subject to rejection. In such case, the Contractor will have to replace the pump with correct pump.

3.6 Diesel Engine Driven Power Generating Sets

Design, manufacture, Supply, inspection at vendor's works, installation, erection, testing & commissioning of 6.6kV DG sets and supply of necessary spare parts.

There shall be minimum Four (4) Diesel Engine Driven Generating sets of required capacity as per design requirements of the Storm Water Pumping Station, designed and rated for continuous duty generally as indicated.

The Bidder shall select kW rating for the engine and kW / kVA rating for alternator based on maximum possible operating loads, as described in detail under clause no. 3.4. The pumps and hence the motors are expected to be low rpm with very low operating PF (Power Factor) for the motor. To meet the excessive kVAr arising out of low PF of the motors, the Bidder shall either

- i) Provide power factor improvement capacitors to supply required kVAr for the connected load (and as approved by DG set manufacturer) or
- ii) Provide alternator with higher kVA rating so that at its rated P.F. of 0.8, it

can deliver required kVAr for the system or a combination of both.

Overall, the DG system shall provide a margin of 15% in terms of kW, kVA and kVAr under maximum permissible load condition.

It is reiterated here that 4 nos. (min) DG sets shall be capable of starting and running of 7 nos. Main pumps under any operating condition at site, not necessarily at duty point only.

Diesel engine shall be complete with Acoustic enclosure meeting noise level restrictions by Pollution Control Boards, Fuel oil system, Lubricating oil system, Lubricating Oil heat exchanger, Cooling system (radiator cooled engine) with heat exchanger, Electrical starting system, Air intake and exhaust system. Necessary equipment such as Jacket water heater etc. to make the engine suitable to start under cold weather conditions shall also be provided.

Generator shall be directly coupled AC generator complete with terminal box, rotating diode type brush-less exciter, automatic voltage regulator, alarm initiating devices, other accessories, independent control panel with controls, instruments and Motors for auxiliary drives.

Diesel Generator set controlling circuit breakers shall be complete with necessary controls, interlocks, Protections, metering and indications as per S.L.D. enclosed. Automatic and Manual synchronizing equipment for 4 nos. (min) DG sets shall also be provided.

Bidders scope of work shall also include obtaining approvals to drawings, designs and installation from all statutory agencies and local authorities concerned. These shall include:

- Chief Electrical Inspector to Government (CEIG)
- Chief Controller of Explosives (CCOE)
- Central and State Pollution Control Board

General

The diesel generating set shall comprise of diesel engine, coupled to a suitable alternator, having brush-less excitation system complete with all accessories. All equipment shall be of the class most suitable for working under the conditions specified and shall withstand the atmospheric conditions without deterioration and without affecting the performance requirements.

Material of construction for interconnecting pipes, pipe fittings, exhaust duct, bolts and nuts shall be as per relevant standards and suitable to withstand the temperature of the gas/liquid within the pipe. All externally mounted hardware can be of cast iron.

Nameplates and labels provided for engine, alternator, control panel and Switchgear, accessories, etc. shall be of stainless steel only.

Operating Conditions

D.G. sets are intended for supplying stand-by power as the most reliable source of supply. The electrical load for diesel generating system shall comprise H.T. motors.

The overall installed capacity of DG sets in terms of KW, kVA and kVAR shall be adequate (at least 15% margin) both during starting of pump sets and during running of pump sets. The starting time of the set shall be kept minimum which has been specified in Technical Particulars. The DG set shall be suitable for parallel operation with DG set of similar rating in synchronized system using auto-synchronization panels.

Design and Construction Requirements

The design parameters of the generator and excitation system shall be so chosen, that the set is stable while running at any load between no-load and full load, and also during starting of motors as specified in Technical Particulars.

Diesel Engine

Material of construction of major parts shall be as per the manufacturer's standards.

The diesel engine shall be multi-cylinder, totally enclosed, rated and designed for continuous operation, direct fuel injection, turbo charged, compression ignition, inter-cooled oil engine. One common base frame shall be provided for mounting the engine, with fly wheel and alternator, complete with foundation bolts, leveling screws, anti-vibration pads. All the engine mounted instruments/control devices shall be wired up to the Local Panel or marshalling box for indication/ annunciation/ interlock purpose. The normal speed of the engine shall be 1500 RPM and the direction of rotation shall be clearly marked on the set. The engine shall be fitted with an exhaust gas driven turbo charger, complete with its own self-contained lubricating system. The turbo charger shall be positioned at free end of the engine. A complete water washing system for turbocharger compressor and turbine shall be provided. The engine shall be fitted with a charge air inter-cooler of the air to water type.

Air from the turbocharger compressor passes to the inter-cooler and then to the engine manifold. The inter-cooler shall be of tubular construction. Crank case extractor fan, complete with motor, filter, suction and discharge piping and other accessories shall be provided if required.

1. Fuel Oil System

The fuel system shall be equipped with a crankshaft driven fuel transfer pump, which shall draw the fuel oil from the day tank via duplex type filters. The standby pump for this shall also be included.

The pre-combustion chamber shall be designed, taking into account the type of fuel used, engine speed, etc., so as to achieve safe knock-free performance with smokeless exhaust. All interconnected piping from day tank to engine, together with piping, fittings, relief valves, return line of surplus oil from the injectors, level control to operate the fuel transfer pump and other accessories shall be supplied by the Vendor.

2. Lubricating Oil System

All lubricating parts of the engine shall be connected to a pressurized lubricating oil distribution piping system, being continuously charged by gear type lube oil pump mounted at the free end of the engine and driven from the engine crank shaft. The pumps shall take suction from a sump tank integral with the engine through a foot valve, suction filter and oil cooler and deliver oil to a main supply header. High-pressure oil shall be supplied to the main and thrust bearings, crankshaft bearings,

governor, auxiliary drive gear, etc. Suitable lubricating arrangement for engine cylinder valve gear, cams and pistons at the required level shall be arranged. A pressure relief valve shall be mounted on the main supply header for safety against too high pressures while starting with cold oil. Motor driven pump shall be furnished in addition, for periodic operation of lube oil system. In case lube oil heater is required, the same shall be furnished.

Duplex filters shall be provided in the Lube oil system to avoid engine failure to take load due to Clogging of Lube filter.

Arrangement to bypass the oil cooler during starting until the oil temperature rises above the minimum shall be provided. The lube oil filter shall be equipped with a bypass valve to prevent engine being starved of oil in case filter is choked.

Pressure switches to give alarm under extreme low pressure of lube oil and subsequently to trip the unit when the minimum safe pressure has been reached shall be provided.

All necessary accessories such as pressure gauges, temperature indicators, pressure relief valves, bypass valves, pressure switches shall be furnished.

3. Cooling System

For the “**Radiator cooled**” design, adequately rated fan driven from engine shaft shall provide cooling air.

4. Engine Starting System

Electrical starting system shall be provided for the engine. Battery of adequate capacity shall be provided with all necessary hardware & accessories along with engine mounted charger (dynamo). A separate source Battery charger shall be provided to keep the battery fully charged under engine – idle condition, providing float and boost charging facilities. The battery shall allow at least 3 re-start attempts before the set is locked out, under normal conditions of the battery.

Sealed Maintenance Free (SMF) batteries suitable for engine starting duly and with a life of at least 3 years shall be provided.

Necessary mechanism shall be provided for automatic starting of engine in conjunction with the fuel oil, lube oil and cooling system scheme. The starting solenoid valves shall be provided with manual bypass valve for local starting.

5. Governing System

The governor shall be driven by cam shaft drive gear and of the **Electronic** type. A mechanical over-speed trip device shall be provided to automatically shut off fuel in case the speed exceeds the prescribed limit.

6. Exhaust System

Engine exhaust system, complete with exhaust gas driven turbo charger, industrial silencer, ducting, bends, separate chimney, silicate lagging, supporting accessories etc. shall be provided. The exhaust shall be taken out of the enclosure. Within the enclosure, the exhaust pipes shall be provided with 22 gauge G.I. cladding.

Stack height shall be 30m. minimum according to provisions of latest CPCB regulations. Each DG set shall be provided with dedicated stack. Stack design along with structural support design shall be subject to Engineer's approval. Necessary catwalk ladders and landing platforms shall be provided to facilitate testing of flue gas samples. The stacks shall be provided with adequate lightning protection as well as aviation lighting as required by aviation authorities.

7. Local Indicator Panel

Engine shall be provided with flexibly mounted local indicator panel with speed indicator and gauges for lubricating oil pressure before and after filter, cooling water temperature.

Generator

The generator shall be industrial type, SPDP, IP21 for indoor application, Class - F insulated, as specified in the Technical Particulars, self-ventilating air cooled, rotating field, salient pole brush-less, AC machine with exciter and shall be rated for the continuous duty. The Generator should be fitted with perforated sheets to protect any foreign particles to reach Winding well as freely allow hot air to come out.

The generator shall have a continuous rating of not less than the value specified at 0.8 P.F. (lag), the specified voltage, rated speed and at site ambient conditions. The generator shall be suitable for operating under the ambient conditions and supply system as specified without exceeding the temperature limits. The generator shall be capable of delivering rated output at rated P.F. with terminal voltage and frequency variation of $\pm 5\%$ from the rated value.

The generator shall withstand without mechanical damage an over-speed of 20% for a period of 2 minutes. All external nuts and bolts shall be of stainless steel only. Generator shall be provided with anti-condensation space heater of adequate rating suitable for 240V, 50 Hz, 1ph AC supply. Two independent earth terminals on the frame, complete with nuts, spring washer, and plain washer shall be provided. The leads of embedded winding RTDs (6 nos.) and bearing RTDs (2 nos.) shall be wired up to the terminal block in a separate terminal box. Manufacturer shall indicate the setting values for each RTD for alarm and trip.

Generator insulation shall be designed to withstand switching surges generated by VCBs. Manufacturer shall indicate the maximum overvoltage surge that it can withstand without deterioration and subsequent damage. Suitable surge suppressors shall be provide for this purpose, in controlling VCB panel.

On-line greasing facility with grease nipples and grease relief device shall be provided. Automatic greasing facility is preferred.

The coil and turns shall be strongly braced to provide thermal and dynamic withstand for transient voltage dip of 15% of rated voltage at generator terminals when largest motor is started.

The rotor shall be dynamically balanced.

All the six terminals of the generator shall be brought out three on phase side and three on the neutral side. Terminal box on phase side shall be used for power connection (cables), the other side a terminal box serving as the neutral terminal box shall be provided for forming neutral. Suitable cable termination box shall be provided

on the output side. Degree of Protection for the terminal boxes shall be IP55. Neutral side terminal box shall be fitted with un-drilled gland plate

1. Short Circuit Conditions

The generator shall be capable of withstanding without injury for 3 sec., 3 phase short circuit at its terminals, when operated at rated kVA and power factor and at 5% over-voltage with fixed excitation.

Machine shall be capable of withstanding without injury any asymmetrical loading on the system, provided that the per unit negative phase sequence component (I_2) of the asymmetrical currents and the duration of short circuit in seconds (t) are limited to values, which give an integrated product $[(I_2)^2 t]$ equal to twenty (20), and also that the maximum asymmetrical phase current does not exceed the max. phase current obtained from a 3 phase short circuit.

2. Unbalanced Stator Current Capability

The synchronous generator shall be capable of continuously operating on an unbalanced system loading such that with none of the phase current exceeding the rated current, the ratio of negative sequence component of the system currents to rated current shall be 8% or more.

3. Momentary Excess current for Generator

The generator shall be capable of withstanding for fifteen- (15) sec. a current of fifty (50) percent in excess of its rated current, the voltage being maintained, as near the rated value as possible, consistent with max. capacity of the prime mover.

4. Stator

The stator core shall be built of high-quality silicon steel laminations, to achieve high permeability with low hysteresis and eddy current losses. The stator shall be mounted such that double frequency vibration set up by action of the field system shall not be transmitted to bearings or the foundation. The stator and windings shall be securely braced and wedged to withstand damage from mechanical and electrical forces imposed on the windings during full voltage short circuit conditions and for the same reason, they have to be heavily insulated.

5. Rotor

The rotor, including field poles, shaft and coupling shall be machined from a solid steel forging. The rotor windings shall be of silver bearing copper. All stresses set up during working in the copper conductor shall be removed by annealing. Joints between coils or half coils shall be brazed to provide high mechanical strength in tension and compression, freedom from excessive annealing, and a clean smooth joint for insulating.

6. Bearings

Self-aligning journal bearings shall be provided and are to be mounted in a housing, forming part of the stator end shields. The babbitt bearing surface shall be solidly bound to the iron or steel shells, such that there are no gas pockets or other voids between the lining and the shell. The self-aligning feature shall accommodate the full range of shaft deflection under all conditions, from standstill to max. over-speed. The bearing

shall be provided with a well with a suitable dial type thermometer in the oil drain and a suitable sight flow opening to observe bearing oil flow. They shall also be provided with Pt-100 type RTDs for monitoring their temperature.

Generator shaft voltage shall not exceed 100 mV. In case the shaft voltage exceeds 100 mV due to magnetic eccentricity, one of the bearings shall be "insulated" type, to prevent large shaft currents. The lube oil pipe to this bearing shall also be insulated. Double amplitude vibration of bearings of the generator and exciter shall not exceed the limit specified in the relevant standards.

The terminal box shall be of the type specified in Annexure - I, suitable for termination of cables as specified. It shall withstand the specified fault current for minimum 0.5 seconds. Adequate clearances shall be provided between terminals and walls of terminal box with minimum air clearance according to the standards.

Separate terminal box shall be provided for space heater and R.T.D./ Thermistor. The location of these additional boxes shall be finalized during approval of G.A. drawing.

The winding leads shall be crimped to tinned copper lugs which in turn will be fixed on copper/brass studs. The studs shall be mounted on porcelain bushings.

7. Damper Windings

The field system shall be provided with adequate damping for satisfactory parallel running to prevent hunting and periodic power swing.

8. Excitation System

The generator shall be provided with a rotating diode type brush-less excitation system, capable of supplying the excitation current of the generator under all conditions of output from no-load to full load and capable of maintaining voltage of the generator constant at one particular value, if operated independently. The exciter shall have Class F insulation.

The excitation system shall comprise a shaft driven AC exciter with rotating rectifiers. The rectifiers shall have in-built protection for over-voltage and rate of rise of voltage. The excitation system shall be capable of forcing the field for more than 3 sec in the event of dead fault at the terminals.

The exciter shall be fast response type and shall be designed to have a low time constant to minimise voltage transients under severe load changes. The excitation voltage response ratio shall be at least 0.8. The rated current of the main exciter shall be at least 10% more than the generator rated excitation current and it shall have a 40% overload capability for 10 seconds. No external supply shall be required during starting and normal running of the generator.

9. Automatic Voltage Regulator

An automatic high speed, dead band type voltage regulator shall be provided, complete with all accessories. The regulation system shall be provided with equipment for automatic and manual control.

The regulator shall regulate the output voltage from generator current and potential signals. Series compounding transformer shall be provided to enable feeding adequate fault current in the event of terminal faults. Alternatively, excitation system shall be

provided with arrangement for field forcing. Vendor shall co-ordinate suitability of protection relays for generator with the operational characteristics of automatic voltage regulator, especially under short circuit conditions.

The regulating equipment shall be housed in engine mounted panel. Voltage regulation from no load to full load and steady state modulation shall be within $\pm 0.5\%$ of the line voltage. Necessary equipment for field suppression and surge protection shall be provided. The response time of the exciter and the generator shall be properly matched to avoid hunting. Necessary equipment shall be furnished to prevent automatic rise of field voltage in case of failure of potential supply. The excitation and voltage regulation shall be designed to cause necessary de-excitation in case of short circuit. Cross current compensation circuit shall be provided.

10. DG system Earthing

The DG neutral is intended to be earthed through a Neutral Grounding Resister (NGR)

- to restrict earth fault currents and
- to minimize damage to stator stamping

The Bidder shall provide NGR having value as recommended by the DG set supplier. All earth fault protections throughout 6.6 kV system shall be compatible for this earth fault current.

An isolator shall be provided in the NGR leg which will facilitate earthing of neutral of only one DG set, as per standard engineering practice.

In addition, following protection shall be provided

- Moisture detection
- Reverse rotation

Induction Motors for Auxiliary Drives

Motors shall be 415V $\pm 10\%$, 50 Hz, $\pm 5\%$ industrial, 3 phase, squirrel cage, IP54, induction motors, conforming to IS325 or equivalent standard (refer cl. 3, Section IIA, Volume II) Each motor shall be painted with chemical works type epoxy paint and windings shall be treated for chemically corrosive atmosphere. Overhang shall be applied with gel coat epoxy paint. Motors shall be Siemens / CGL / BB make.

The motor shall be provided based on the following requirements:

- a) The motor rating shall be 15% higher than the driven equipment input power requirement.
- b) The winding insulation shall be class B.
- c) The locked rotor withstand time shall be more than the accelerating time of the motor.
- d) The motor shall be able to start at 80% of the rated voltage.

DG Controlling Switchgear

The 6.6 kV switchgear shall be in accordance with the S.L.D enclosed and general specifications for 6.6 kV switchgear. Details such as device ratings, metering, indications, alarms, controls and protections are furnished in the S.L.D. The entire system shall be suitable for control from PLC and shall interface with SCADA system proposed to be implemented under this Project. The scope of work shall also include supply of automatic and manual synchronisation panel for all the 4 sets. Proprietary GCU (Generator Control Unit) shall be provided for complete control and operation of DG set. Auto-exercising shall be with field audio pre-warning with 3 minutes delay for safety of operating and maintenance staff. Start and Stop control will be from the PLC, which will be governed by number of pumps that are required to run. The control panel shall also provide facility for load sharing in terms of active and reactive power. Multi-function meter to be provided on the switchgear shall communicate with SCADA system to transfer data on electrical parameters of each DG set.

Power and Control Cables

All power cables required for auxiliary drives for D.G. set will be of 1100 V grade, aluminium / copper conductor, PVC insulated, extruded PVC inner and FRLS PVC outer sheathed, steel strip/round wire armoured. Minimum size of conductor for power cables will be 4.0 mm² aluminium. Control cables will be of 1100 V grade, stranded copper conductor of minimum 1.5 mm² size PVC insulated, extruded PVC inner and outer sheathed, steel strip/wire armoured.

Painting

Machined and finished surfaces shall be protected against formation of rust and corrosion by application of suitable rust inhibitors. All steel surfaces, which are to be painted, shall be thoroughly cleaned, degreased and applied with two coats of epoxy-based primers. Assembly shall be cleaned before painting. All exterior surfaces shall be painted with two coats of epoxy-based paint shade 631, as per IS-5 or equivalent standard (ref. cl. 3, Sec IIB, Volume II). Adequate quantity of touch up paint shall be furnished for application after installation.

Tests

Tests shall be carried out during and after completion of manufacture of different component parts and the assembly, as applicable, in accordance with the requirement of relevant codes and standards. Vendor shall indicate other tests, which are required to be carried out at site after installation.

Tests shall be performed in presence of Purchaser's representative if so desired by Purchaser, at Supplier's works on completed assembly of the DG set. The Vendor shall give at least two (2) weeks advance notice for inspection.

The generator shall be subjected to following tests (for which only Test Certificates are required):

- a) High voltage tests on stator and rotor windings.
- b) Insulation resistance of stator and rotor windings.
- c) Temperature rise test
- d) Open circuit and short circuit tests.
- e) Stator phase sequence check.

- f) Overload capability test.
- g) Measurement of air gap.
- h) Stator winding resistance measurement

Excitation System

The excitation system shall be subjected to the following tests at manufacturer's works (for which only Test Certificates are required):

- a) High voltage tests on windings.
- b) Insulation resistance of windings.
- c) Temperature rise test.
- d) Measurement of resistance of stator and rotor windings.
- e) Open circuit magnetization test.

The voltage regulator shall be subjected to the following tests at manufacturer's works (for which only Test Certificates are required):

- a) Sensitivity test.
- b) Response time test.

The control panels shall be subjected to the following tests at manufacturer's works, which shall be witnessed by the Purchaser/ his representative.

- a) Functional Test
- b) High voltage withstand test as per relevant standard.
- c) Insulation resistance test.

Functional and operation test.:

D.G. set and the auxiliaries shall be assembled at the manufacturer's works and the following tests shall be performed, which shall be witnessed by the Purchaser / his representative.

- a) One (1) hour running at full load.
- b) One (1) hour running at 3/4 load.
- c) One (1) hour running at 110% full load.
- d) Engine starting time.
- e) Fuel consumption test.
- f) Power run of auxiliary equipment
- g) Functional checks of control and protective devices

Before each test, the engine shall be brought to a steady state under the conditions of the test.

Tests at Site

The tests shall be performed after proper installation of the diesel generating unit at site to prove the proper operation of interlock circuits and the capability of the engine to start and pick-up load in the specified time, under supervision of the purchaser's representative responsible for supervision of testing and commissioning. Guarantee tests to prove guaranteed performance of the D.G. set shall also be carried out at site after proper installation.

Test Certificates

- a. Test certificates shall be submitted in six (6) copies.
- b. The test certificates shall be furnished to the purchaser for prior approval before despatch of any equipment from works and the approval in writing from purchaser shall be essential to effect dispatch of the equipment.
- c. The test reports shall indicate complete identification of the data, including serial number of each equipment.

Special Tools & Tackles

The Supplier shall furnish to the purchaser a complete and unused set of all special tools and tackles, which are necessary or convenient for erection, testing and commissioning, maintenance and overhauling of any of the equipment provided under this specification.

The tools shall be shipped in separate containers clearly marked with the name of equipment for which they are intended.

The Supplier shall submit a list of tools proposed to be furnished under the scope of supply with his proposal.

Spare Parts

The Supplier shall submit a list of recommended spare parts, with suggested quantities and catalogue numbers, for two (2) years smooth and trouble-free operation, along with item-wise price for each item of spare parts.

Erection, Testing and Commissioning

The Vendor shall carry out Erection, Testing, final checking and commissioning at site and put the D.G. set into successful commercial operation as a part of this Contract.

Guaranteed Performance

The performance figures quoted in the technical particular sheets shall be guaranteed within the tolerance permitted by relevant standards. In case of failure of equipment to meet the guarantee, the purchaser reserves the right to reject the equipment. However, purchaser reserves the right to use the rejected equipment until the vendor supplies the new equipment meeting the guarantee requirements.

Technical Particulars

3.5.15.1	Application	Power Generation at 6600 V
3.5.15.2	Ambient Temperature	40 deg. C
3.5.15.3	Generator & Voltage Regulator	

1	Output rating, minimum acceptable	kW rating for the engine and kW / kVA rating for alternator to be based on Maximum possible operating loads (Refer clauses 3.4 & 3.5 also)
2	Rating	Continuous duty
3	Power factor	0.8 Lag
4	Class of Insulation for Stator & Rotor	Class F with temp rise limited to Class B
5	Rated voltage & frequency	3 phase, 3 wire, 6600V, 50 Hz
6	Neutral earthing	Through NGR controlled by an isolator
7	Winding connection	All six leads of the windings for Generator shall be brought out in terminal box. Three on one side for phase connections to DG CB and three on the other side where the neutral is formed. Phase side : 3C x 240mm ² Al / XLPE cable Neutral side : 3C x 240mm ² Al / XLPE cable
8	Maximum permissible time for building up rated voltage from standstill and closing of D.G. breaker	Less than 8 sec
9	Variation of voltage from no load	± 1% of rated voltage on auto mode to full load
10	Output voltage adjustment range	± 5% of rated voltage
11	Capacity of largest motor to start	Submersible pump motor of rating (kW) as specified in cl. 3.4 to start with soft starter with another submersible pump motor already running on the DG set
12	Dynamic voltage response and permissible voltage drop at motor terminals during operating condition starting	20% of rated voltage at generator terminals as per 3.11 above Largest rating motor
13	Maximum over-speed for 2 min over the entire range of output	120% of rated speed

14	Type of excitation system	Brush-less, rotating diode
15	Type of control for voltage regulator	From engine control panel, Manual & Auto
3.5.15.4	Engine	
1	Type of fuel for engine	High speed diesel (HSD)
2	Day oil tank capacity	Adequate for 4 hours continuous full load operation (max. 990 liters)
3	Maximum permissible starting time for Attaining full speed and closing of generator breaker	Less than 8 sec
4	Engine speed	1500 RPM
5	Starting system	Electrical starting with batteries
6	Type of Governor	Electronic with mechanical over-speed protection
7	Lubrication system	Pressure fed type
8	Cooling system	Radiator cooled design
3.5.15.5	Acoustic enclosure	Required. To restrict sound pressure level to 75 dB (A) at 1.0 m from enclosure surface. The enclosure shall be sheet metal fabricated (CRCA) and shall be epoxy powder coated with shade RAL 7032. This shall be suitable for installation outdoor and shall be suitably protected from corrosion due to marine environment. Adequate space shall be provided inside the enclosure for free movement of the operating personnel around the DG

3.7 Auxiliary Diesel Generator Set

Scope:

This specification covers the design, construction features, manufacture and performance of emergency diesel generator. The scope includes supply, installation, testing and commissioning of DG set of suitable kVA rating (minimum 62.5kVA) along with fuel pipeline complete with Base frame, acoustic enclosure, AMF panel, exhaust chimney with residence type exhaust pipe insulation and all the accessories required for trouble free operation.

Codes and Standards:

The DG set shall meet the requirements of the following standards and rules:

IS : 2253	Designation for type of construction and mounting arrangement of rotating electrical machines.
IS : 4691	Degree of protection providing by enclosures of rotating electrical machinery.
IS : 4728	Terminal marking of rotating electrical machines.
IS : 7132	Guide for testing 3 Phase Synchronous Machines.
IS : 5422	Turbine type generators.
IS : 4889	Methods of determination of efficiency of rotating electrical machines.
IS : 1271	Insulating materials for Electric machinery and apparatus in relation to their thermal stability service, classification.
IS : 4722	Specification for rotating electrical machines.
IS : 13947	AC circuit breakers.

Use of equivalent standards of other countries or organisations may be permitted (ref cl.2., Section IIA, Volume II)

Design Conditions:

All equipment and materials will be selected and rated for use at the following site conditions.

Summer outdoor design temperature	50° C.
Surface temperature	80° C.
Relative Humidity	95% Max.

Design & Construction :

GENERAL:

- A) The diesel engine offered shall be of the regular production models of the manufacturer for industrial applications and already type tested either at the manufacturer's works or outside. The type test report shall be furnished to the purchaser for his review if so desired.

In case the proposed engine model has not been type tested, vendor shall furnish with the offer, a reference list of its existing industrial installation and at least three of these engines, should have completed, 5000 hours of running at site.

- B) Unless otherwise specified in the equipment data sheets, the diesel engine shall be provided with class A1 governing as per the latest edition of B.S. 5517 or equivalent standard (ref cl. 3, Section IIA, Volume II).
- C) The “Cyclic irregularity” of the diesel engine for direct coupling to an electric generator, “angular deviation of A.C. generators” given by diesel engine for parallel operation, and the “engine governor speed droop characteristics”, shall be restricted to the values specified under the latest edition of B.S. 5517 equivalent standard (ref cl. 3., Section IIA, Volume II).
- D) The vendor shall be responsible for carrying out torsional analysis of the dynamic system as specified in the latest edition of British Standard-5517 equivalent standard (ref cl. 3., Section IIA, Volume II). The results in the form of a report shall be submitted to the purchaser for scrutiny and reference, if desired.
- E) Vendor shall provide the flexible exhaust connections to connect the engine exhaust to the exhaust piping. The required size of the exhaust piping should be clearly specified by the vendor.
- F) The common base plate for mounting the diesel engine and the driven equipment as well as the flexible coupling, shall be supplied by the vendor.
- G) Vendor shall indicate in the bid, the IS Noise Level rating of the diesel engine with the offered exhaust silencer when measured at 1m distance from enclosure surface should not exceed 75 db at 1 Mtrs.

ENGINE STARTING:

- A) Diesel engines shall be capable of starting without the use of cold starting aids so long the ambient temperature at the site is not below 4° c.
- B) Where the diesel engine is specified / offered with battery starting arrangement, the starter motor shall be capable of starting the engine without having to disengage the driven machine with the help of a clutch. Where the diesel engine is equipped with a dual starter the synchronizing switch and the corresponding wiring / connection with the starter motor shall be provided by the vendor.

In case of diesel engines driving the engine mounted battery charging alternator, the Vendor shall also provide Battery, automatic Electronics float & boost type battery charger suitable for taking power from supply authority's power source and mounted on a free standing type of a panel.

The battery charger as specified in the equipment data sheet, shall be capable of delivering a current equal to 100% of the 20 hour discharge rate of the battery and also equipped with charging rate selector device.

As specified in the data sheets, the diesel engine is required to start / stop automatically, the vendor shall provide the necessary controls (automatic - cum -manual) in the engine panel and the interconnecting wiring and piping from the panel to the engine and starting equipment. A pilot lamp shall be provided in the line side of the starting equipment circuit to indicate that the controller is in the automatic position. In the event the engine does not start after three attempts have been made, the controller shall stop all further cranking and operate the audio-visual alarm. Shaft driven lubrication system is acceptable, alternatively D.C. motor driven lubrication pump with timer suitably interlocked with the starting system is acceptable.

Engine Cooling:

Vendor shall supply radiator-based cooling system.

Engine Fuel System:

Engine fuel system shall be complete in all respects but not limited to following:

- A) The day tank shall be equipped with shielded level gauge, strainer and a hand hole of not less than 150mm diameter, besides the required fuel connections and a drain plug. One tanks of suitable capacity to be provided.
- B) The inside surfaces of the fuel tank and the float tank shall be coated with Enamel Red or Black of I.C.I. or its equivalent and the outside surface to be given two coats of the oil resistant primer paint. The fuel tank shall be hydrostatically tested at a pressure not less than 0.35 Kg./Cm.²
- C) Fuel oil transfer pump to transfer oil from barrels to day tank shall also be provided.
- D) All piping, valves, fittings and supports inside D.G. house shall be part of supply.

Inspection & Testing :

- A) The vendor shall have the responsibility of providing purchaser's representative with all requisite facilities / equipment for carrying out satisfactory testing.
- B) The diesel engines shall be tested in the presence of purchaser's representative accordance with latest edition of B.S. 5514 or equivalent standard (ref cl. 3., Section IIA, Volume II).
- C) The routine load and fuel consumption test shall be of the 4 hours.
- D) Unless otherwise specified, 10% overload provision shall be kept while setting the fuel limit for the site running.
- E) The engine control panel/s after assembly and wiring shall be functionally tested in the presence of the client's / consultant's representative.

Alternator :

- A) This specification defines the requirements of design, manufacture, testing and supply of self-excited emergency generator complete with automatic voltage regulator, control panel, isolator and other accessories as specified in the material requisition.
- B) Unless otherwise specified the emergency generator shall be supplied complete with:
- Electric panel including control cubicle and associated auxiliary devices, relay panel and generator breaker / isolator, battery and battery charger.
 - Air inlet and outlet for generator cooling (inlet shall be oriented to suit total plant layout).
 - Lifting arrangement for the machine.
 - Foundation frame complete with foundation bolts to install along with engine on common base frame.
 - Lube oil system integral with the prime mover lube oil system.
 - Spares for commissioning.
 - Spares for two years of operation and maintenance.
 - Any other part / accessories not specifically mentioned above but considered necessary for safe and reliable operation.

C) DESIGN AND CONSTRUCTION:

The alternator design shall meet the requirement specified in data sheet and shall be suitable for the site conditions specified therein.

- The alternator shall be mounted on a common base frame together with the prime mover unless otherwise agreed. The generator shall be provided with necessary lifting hooks and two earth terminals for connection to main earth grid.
- The alternator winding shall be class "F" insulation with temperature limitation to Class "B".
- The stator windings shall be brought out to six insulated terminals in two separate terminal boxes. The alternator shall, therefore, be provided with three separate terminal boxes i.e. for the line and neutral stator connection and for control connection. The terminal box for the line terminal shall have 40 % free space and each segregated for easy cable end connection of cable size specified in data sheet. The neutral box shall in addition to the space for neutral earthing cable shall have sufficient room for the current transformers used for the protection of the generator. Star connection shall be formed in the neutral side of terminal

box. The terminal box for control cable shall contain properly marked terminals for all internal equipment e.g. embedded temp. detectors etc. All terminals shall be stud type. The terminal boxes shall be complete with lugs and double compression type cable glands. Current transformers shall be as specified in data sheet.

- All parts and accessories shall be suitable to withstand stresses due to over speed / overload / short circuit conditions specified.
- Bearings shall be double shielded and pre-lubricated. Grease in the bearing enclosure shall provide additional lubrication to bearings as well as provide sealing against dust and moisture. On line greasing facility with excess grease expulsion system shall also be provided.
- The alternator shall be air cooled unless otherwise agreed, alternator enclosure shall be as specified in data sheet.
- The direction of rotation of the rotor of the machine shall be compatible with that of the prime mover. A clear indication of the direction of rotation shall be given on either end of the machine.
- Field winding shall have class "H" insulation with excellent electrical and mechanical properties. The field winding shall be capable of operating at a field voltage with Excitation capacity $E_{max} / E_n = 1.6$ for at least two minute to meet improved stability requirements.
- A rating plate of SS material shall be fixed on the generator frame and shall give the following information :
 - a) Manufacturer's name.
 - b) Serial Number, Type and frame reference
 - c) Rated output in KVA & KW
 - d) Rated power factor, frequency and voltage
 - e) Rated stator current and speed in Rev. / Min.
 - f) Class of insulation
 - g) Phase rotation (CW or CCW)
 - h) Customer's indent no.
 - i) Year of manufacture
 - j) Weight of rotor and stator in Kg.

Generator Control Panel with AMF facility:

The local generator control panel for the generator set shall comprise the following unless otherwise specified in the attached data sheet.

- Electronic Multi-function Meter (kWH, PF, kW, Ammeter, Voltmeter, Frequency)
- DC Ammeter, DC Voltmeter.
- AMF facility
- Tariff metering kWh meter
- Indicating instruments. (Indicating lamps for load on DG / Mains, Mains available, battery charger input supply on, 24 V DC supply on)
- Current operated relay (overcurrent and earth-fault protections)
- Motorised MCCB for DG set.
- Battery charger along with DG & Mains selector switch
- Lube Oil motor start / stop, if motor driven lubricant oil system
- Annunciation windows (8 Nos.) for electrical fault & engine fault
- Ammeter protector relay.(Reverse power relay, over current & Elf. Relay)
- Current transformers

Any other accessory require to make the generator set operational as a package shall be included in scope of supply. If required the generator control panel shall be split into various functional sections viz. protection, metering and control, regulation etc.

The panel shall be free standing, metal enclosed, dust and vermin proof type with a hinged door and having a degree of protection IP 51 as per IS : 13947 unless otherwise specified. Power and control equipment shall be segregated inside the panel as far as practicable. The maximum height of the operation handle/ switches shall not exceed 1500 mm. and the minimum height not below 300 mm. All hardware shall be corrosion resistant and bolts, nuts and washers shall be made of galvanised zinc passivated or cadmium plated high quality steel. Unless otherwise specified the panel shall be suitable for bottom cable entry. Necessary double compression glands shall be provided with the panel.

All auxiliary devices for control, indicator, measurement and alarm such as push buttons control / selector switches, indicating lamps, metering instruments, annunciations etc. shall be mounted on the front door of the panel. Adequate number of potential free contacts shall be provided in the control panel for any remote control, monitoring of the generator set.

Wiring for power, control and signaling circuits shall be done with FRLS insulated copper conductors having 660 / 1100 V grade insulation. Minimum size of control wires shall be 1.5 mm. Terminals shall be acceptable for wires up to 10 mm.² size and for conductors larger than 10 mm.² bolted type terminals with crimping lugs shall be provided. A minimum of 10% spare terminals shall be provided on each terminal block.

An adequately sized earth bus shall be provided in the panel for connection to the main earth grid. All non-current carrying metallic parts of the mounted equipment shall be earthed. Doors and movable parts shall be earthed using flexible copper connections.

Engraved nameplates shall be provided for all devices mounted on the front of the panel. Name plate or polyester adhesive stickers shall be provided for each equipment mounted inside the panel.

Painting, Packing and Transport:

All metal surfaces shall be thoroughly cleaned of scale, rust and grease etc. prior to painting. Cleaned surfaces shall be given two coats of primer and prepared for final painting. Final finish shall be free from all sorts of blemishes.

The equipment shall be shipped to site suitably packed to prevent any damage. Each package shall have labels to show purchaser's name, purchase order and equipment no. suitable lifting lugs etc. shall be provided and lifting points shall be clearly marked on the package. Packing shall be suitable for storage at site for a minimum period of 6 months.

Tests And Inspection:

The owner or his authorised representative may visit the works during manufacture of equipment 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 all assistance to carry out the inspection. Detailed test procedure along with the facilities available at vendors works shall be furnished along with the bid Owner's representative shall be given minimum four weeks advance notice for witnessing the final testing. Test certificates including test records and performance curves etc. shall be furnished for the complete D.G., individual test certificates of engine / alternator / common panel should be submitted, only thereafter complete D.G. would be tested.

TESTS :

Equipment shall be tested to conform to the appropriate standards and the following tests shall be conducted in the presence of purchasers:

- a) Functional tests, continuity tests and high voltage test on control panel to establish the performance called for in the specification.
- b) Power frequency voltage test on switch gear and mechanical / electrical operational check.
- c) Routine tests for alternator as per IS: 4722 or equivalent standard (ref cl. 3., Section IIA, Volume II).
- d) Over speed test (1.2 times the rated speed for 2 minutes.)
- e) Transient response tests for sudden application and rejection of loads of 25%, 50%, 75% and 100% of rated capacity.

- f) Phase sequence test.
- g) Vibration test.
- h) Noise level test.
- i) Dimensional and alignment test.
- j) Wave form test.

NOTE :

1. The engine H.P. should be selected so as to achieve required KW rating to be generated at site condition and de-rated considering temperature inside acoustic enclosure.
2. Black start D.G. set should be able to start by full-fledged AMF panel.
3. The engine test shall be witnessed by the OWNER's representative.
4. The engine should have automatic belt tensioning arrangement for battery charging alternator system.
5. The engine should have facility for the indication of oil level in oil sump during running of the engine.
6. The noise level should not be more than 95 db at 3 Mtrs. Distance and engine exhaust smoke emission level should be less than 1 bosch.
7. Engine should be preferably from the engine manufacturers who maintain quality assurance to international standard of ISO 9001.
8. Engine should be fitted with electronic governor only.
9. The engine water circular pump should be directly driven by engine gear system. V-belt driven system should not be adopted / accepted.

3.8 Fuel Storage & Transfer Systems comprising of Main Diesel Storage Tank and Fuel Transfer system from main tank to Day Tank:-

The Contractor shall obtain necessary permissions and prior approvals from the fire officer, police department and Chief Controller of explosives for bulk diesel storage and for design, general arrangement and layout of bulk storage tank as well as fuel transfer system before proceeding with manufacturing / procurement / installation of the fuel transfer system.

The tanks shall be Floor mounted fabricated using MS sheet, duly sand blasted and painted using epoxy paint and fitted with inlet, outlet and return connections, air vent, drain valve and level indicator and level switches and a separate MCC for fuel transfer pumps. Complete installation in the Diesel storage yard i.e. area lighting fixtures in fuel storage area shall be flame proof and shall be approved by the concerned authority.

Main storage tank shall be provided with Lo-Lo, Lo and Hi level switches.

Lo-Lo level switch shall stop all the fuel transfer pumps to day tanks

Lo level switch shall provide alarm for operating shaft for replenishment of fuel.

Hi level switch shall stop fuel unloading pump and prevent overflow of main storage tank.

One small mild steel day tank of cylindrical / rectangular construction and of 990 liters capacity shall be provided near each DG set. The day tank shall be suitably located and shall be complete with gauge glasses, filling, draining and vent connection with valves and level switches for low oil level, low-low oil level & high oil level alarm and automatic operation scheme for day-tank filling.

Each day tank shall be provided Lo-Lo, Lo and Hi level switches for control of fuel transfer pump and DG set running.

Lo-Lo level switch shall stop DG operation

Lo level switch shall initiate running of fuel transfer pump

Hi level switch shall stop the fuel transfer pump.

All above level switches shall be annunciated on a central control panel for the entire system and/or VDUs of the SCADA/PLC system

The transfer of fuel from Main tank to Day tank shall be using fuel transfer pumps (1 working and 1 standby) installed nearby the underground tank which will operate based on signal transmitted by the level switches provided in the day tank so that when the day tank is nearing low level, the transfer pumps shall replenish the day tank immediately. Each fuel transfer pump, pumping fuel from Main storage tank to Day tanks through a common header, shall be sized to fill up all day tanks in 30 minutes.

All components used for fuel transfer system including local push buttons, all components used in the control panel, fuel transfer pumps etc. shall be flameproof.

The tenderer shall specify the data regarding the consumption of diesel per unit of power generation.

3.9 Fuel Storage & Transfer Systems comprising of Day Tanks and Fuel Transfer system from Day tank to Main DG Sets

The Contractor shall obtain necessary permissions and prior approvals from the fire officer, police department and Chief Controller of explosives for bulk diesel storage and for design, general arrangement and layout of bulk storage tank as well as fuel transfer system before proceeding with manufacturing / procurement / installation of the fuel transfer system.

One small mild steel day tank of cylindrical / rectangular construction and of 990 liters capacity shall be provided near each DG set. The day tank shall be suitably located and shall be complete with gauge glasses, filling, draining and vent connection with valves and level switches for low oil level, low-low oil level & high oil level alarm and automatic operation scheme for day-tank filling.

Each day tank shall be provided Lo-Lo, Lo and Hi level switches for control of fuel transfer pump and DG set running.

Lo-Lo level switch shall stop DG operation

Lo level switch shall initiate running of fuel transfer pump

Hi level switch shall stop the fuel transfer pump.

All above level switches shall be annunciated on a central control panel for the entire system and/or VDUs of the SCADA/PLC system

The transfer of fuel from Main tank to Day tank shall be using fuel transfer pumps (1 working and 1 standby) installed nearby the underground tank which will operate based on signal transmitted by the level switches provided in the day tank so that when the day tank is nearing low level, the transfer pumps shall replenish the day tank immediately. Each fuel transfer pump, pumping fuel from Main storage tank to day tanks through a common header, shall be sized to fill up all day tanks in 30 minutes.

All components used for fuel transfer system including local push buttons, all components used in the control panel, fuel transfer pumps etc. shall be flameproof.

The tenderer shall specify the data regarding the consumption of diesel per unit of power generation.

3.10 Fuel Storage & Transfer Systems comprising of Day Tank and Fuel Transfer system from Day tank to Aux. DG Set:-

The Contractor shall obtain necessary permissions and prior approvals from the fire officer, police department and Chief Controller of explosives for bulk diesel storage and for design, general arrangement and layout of bulk storage tank as well as fuel transfer system before proceeding with manufacturing / procurement / installation of the fuel transfer system.

One small mild steel day tank of cylindrical / rectangular construction and of 990 liters capacity shall be provided near each DG set. The day tank shall be suitably located and shall be complete with gauge glasses, filling, draining and vent connection with valves and level switches for low oil level, low-low oil level & high oil level alarm and automatic operation scheme for day-tank filling.

Each day tank shall be provided Lo-Lo, Lo and Hi level switches for control of fuel transfer pump and DG set running.

Lo-Lo level switch shall stop DG operation

Lo level switch shall initiate running of fuel transfer pump

Hi level switch shall stop the fuel transfer pump.

All above level switches shall be annunciated on a central control panel for the entire system and/or VDUs of the SCADA/PLC system

The transfer of fuel from Main tank to Day tank shall be using fuel transfer pumps (1 working and 1 standby) installed nearby the underground tank which will operate based on signal transmitted by the level switches provided in the day tank so that when the day tank is nearing low level, the transfer pumps shall replenish the day tank

immediately. Each fuel transfer pump, pumping fuel from Main storage tank to Day tanks through a common header, shall be sized to fill up all day tanks in 30 minutes.

All components used for fuel transfer system including local push buttons, all components used in the control panel, fuel transfer pumps etc. shall be flameproof.

The tenderer shall specify the data regarding the consumption of diesel per unit of power generation.

3.11 EOT Crane for Axial Flow Pumps

The contractor shall supply, test, install and commission EOT crane of minimum SWL capacity twice the maximum weight of equipment / component to be lifted, as per below mentioned specifications (refer 3.10.1 and 3.10.2) including rail section complete with Control pendant, control panel, cables, maintenance platform, caged ladder, extension structure and allied work for lifting, shifting Main submersible pumps inside the pump house during maintenance purposes. The EOT shall also be provided with an extension as per approved G.A. drawing for transfer of pumps during loading or unloading.

General requirements:

All EOT Cranes shall be designed and constructed in accordance with IS:3177 /BS 2573 and shall comply with the requirements of BS 466: Class 2 medium-duty operation. Use of equivalent standards of other countries or organisations may be permitted. The term 'crane' shall be deemed to include gantry rails, platform with handrails for maintenance use, down-shop conductors, end stops, holding-down bolts and all other items required for complete installation. Mechanisms shall be design in accordance with ISO 4301. All the EOT cranes shall be manufactured as per drawings and designs approved by the Engineer.

The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that plates more than 20 mm 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 skewness. 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. The crane rails shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100,000 hours. Electro-magnetic and 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.

Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS:2903 / BS:3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

Hoist rope shall be extra flexible, improved plough galvanised steel rope with well lubricated hemp core. The ropes shall conform to IS:2266. Rope drums shall be grooved and shall be either cast iron or cast steel or welded steel conforming to IS:3177, BS:466 or relevant internationally approved standards.

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 and BS:721 or relevant internationally approved standards.

Cranes shall be prominently marked / inscribed with safe working load (SWL) on each side of the crane bridge girders readily legible. Crane hooks shall be fitted with safety latches and the hook block shall incorporate fully guarded rope sheaves. The maintenance platform shall be designed to provide safe access to the crane machinery and all high-level lighting and roof-mounted ventilation plant. Access to the platform shall be by fixed stairway from a convenient point in the concerned building.

Each EOT Crane operation shall be by control pendant from ground floor level.

EOT Crane shall be labeled or marked with the safe working load (SWL) and the purpose for which they are intended. The crane, and all other lifting equipment supplied shall be tested by the manufacturer at his works and test certificates shall be submitted by the Contractor.

Before EOT Cranes are put to use for any purpose whatsoever it shall be tested at site to lift and maintain a minimum test load of 125% of the safe working load. During this overload test each movement in turn shall be maneuvered and the EOT Crane shall sustain the load under full control. The Contractor shall provide the necessary test loads and shall carry out the tests in presence of engineer of the Contract, who will require to measure deflections and record other observations.

The maximum deflection under full load shall not exceed 1/900 of the span (as per IS:3177).

The test loads shall be removed from site by the Contractor after successful tests have been completed.

Suitable lifting slings, shackles, lifting beams, wire ropes, etc. shall be supplied by the Contractor at no extra cost to MCGM during entire period of testing, commissioning, operation and maintenance.

Use of equivalent standards of other countries or organisations may be permitted (ref. cl. 2, Section IIA, Volume II).

Electrical requirements:

All movements shall be electrically powered and be suitable for operating with the hook fully loaded. Motors shall be of the quick-reversing type with electro-mechanical brakes suitable for the duties specified. All motors shall be TEFC with IP 55 enclosure designed for operation at $415\text{ V} \pm 10\%$, $50\text{ Hz} \pm 5\%$. Limit switches shall be incorporated to prevent excess travel, or over-hoisting and over-lowering of the crane hook. Facilities shall be provided for the accurate location of the hook by means of 'inching' all the motions.

Crane operation shall be from ground floor level by bridge-mounted pendant push-button controls. Controls shall be mechanically and electrically interlocked to prevent inadvertent operation of opposing motions. The pendant shall be supported independently of the electric cable and shall be arranged for extending for operation when necessary. Down-shop conductors shall be of the fully-insulated shrouded busbar type. The current collectors shall have renewable contact pieces. Festoon cables may be used for cross travel. A crane isolator, lockable in the 'Off' position and incorporating a warning lamp, illuminated when the supply is 'On', shall be provided at the bottom of the access ladder. A second isolator shall be provided at the control cubicle located on the crane platform.

All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, 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 conductors manufactured from high conductivity hard drawn copper. 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.

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. The Contractor shall supply all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and protection in case of power supply failure. All electrical equipment shall be fully tropicalised. Motors and switchgear shall be provided with anti-condensation heaters, which shall be energised when the crane is at rest, and suitable warning notices shall be provided.

3.12 EOT Crane for Coarse Screens and Trash Racks

An electrically operated overhead travelling gantry crane / EOT crane of minimum SWL capacity twice the max. weight of equipment / component to be lifted. The Gantry crane / EOT crane will have longitudinal movement to cover entire width of nallah bound by retaining walls downstream of the culvert and cross movement spanning Screens, Trash racks and the silt pit in front of screens on upstream side. This Gantry crane / EOT will be designed for Lifting of Screens from their position during maintenance and installation requirements. This Gantry / EOT shall have provision of grab designed for removal of large and small sized suspended / deposited materials, debris, rags, plastics and bottles, dead animal bodies, tree branches and such deposits from the pit. This Gantry / EOT crane shall facilitate collection and disposal of removed screenings up to the disposal point inside plot boundary adjacent to compound wall. A laydown area adjacent to the screens will be constructed to facilitate loading and unloading of removed screens. The EOT shall be provided with cabin operation facility including control panel, cables, maintenance platform, caged ladder and allied works for covering movements of EOT throughout entire width of screens area.

General requirements:

All EOT Cranes shall be designed and constructed in accordance with IS:3177 /BS 2573 and shall comply with the requirements of BS 466: Class 2 medium-duty operation. The term 'crane' shall be deemed to include gantry rails, platform with handrails for maintenance use, down-shop conductors, end stops, holding-down bolts and all other items required for complete installation. Mechanisms shall be design in accordance with ISO 4301. The EOT crane shall be manufactured as per drawings and design approved by the Engineer.

The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that plates more than 20 mm 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 skewness. 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. The crane rails shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100,000 hours. Electromagnetic and 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.

Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS:2903 / BS:3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

Hoist rope shall be extra flexible, improved plough galvanised steel rope with well lubricated hemp core. The ropes shall conform to IS:2266. Rope drums shall be grooved and shall be either cast iron or cast steel or welded steel conforming to IS:3177, BS:466 or relevant internationally approved standards.

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 and BS:721 or relevant internationally approved standards.

Cranes shall be prominently marked / inscribed with safe working load (SWL) on each side of the crane bridge girders readily legible. Crane hooks shall be fitted with safety latches and the hook block shall incorporate fully guarded rope sheaves. The maintenance platform shall be designed to provide safe access to the crane machinery and all high-level lighting and roof-mounted ventilation plant. Access to the platform shall be by fixed stairway from a convenient point in the concerned building.

The EOT Crane operation shall also be by control pendant from ground floor level.

EOT Crane shall be labeled or marked with the safe working load (SWL) and the purpose for which they are intended. The crane, and all other lifting equipment supplied shall be tested by the manufacturer at his works and test certificates shall be submitted by the Contractor.

Before EOT Cranes are put to use for any purpose whatsoever it shall be tested at site to lift and maintain a minimum test load of 125% of the safe working load. During this overload test each movement in turn shall be maneuvered and the EOT Crane shall sustain the load under full control. The Contractor shall provide the necessary test

loads and shall carry out the tests in presence of engineer of the Contract, who will require to measure deflections and record other observations.

The maximum deflection under full load shall not exceed 1/900 of the span (as per IS:3177).

The test loads shall be removed from site by the Contractor after successful tests have been completed.

Use of equivalent standards of other countries or organisations may be permitted (ref. cl. 2, Section IIA, Volume II).

Suitable lifting slings, shackles, lifting beams, wire ropes, etc. shall be supplied by the Contractor at no extra cost to MCGM during entire period of testing, commissioning, operation and maintenance.

A trolley mounted moving grab shall be fixed on to the cross travel adjacent to the hoist mechanism. arrangement.

While designing the grab mechanism and the material of construction of grab, following factors should be taken in to consideration:-

- The components of grab mechanism will be subject to alternate drying and wetting during the course of operation.
- The grab will be operated in storm water severe environmental conditions like exposure to marine environment, natural tides and wave action, exposure to brackish and saline water
- The grab will be subjected to impact load during each downward movement
- The grab will be subjected to abrasion on account of concrete structures, debris and deposits.
- removal of deposits / large objects of about minimum 1000 kg per grab or volume equivalent to minimum 1 m³ of refused collectibles during one stroke / objects

Electrical requirements:

All movements shall be electrically powered and be suitable for operating with the hook fully loaded. Motors shall be of the quick-reversing type with electro-mechanical brakes suitable for the duties specified. All motors shall be TEFC with IP 55 enclosure designed for operation at 415 V +- 10%, 50 Hz +-5% Limit switches shall be incorporated to prevent excess travel, or over-hoisting and over-lowering of the crane hook. Facilities shall be provided for the accurate location of the hook by means of 'inching' all the motions

Crane operation shall be from ground floor level by bridge-mounted pendant push-button controls. Controls shall be mechanically and electrically interlocked to prevent inadvertent operation of opposing motions. The pendant shall be supported independently of the electric cable and shall be arranged for extending for operation when necessary. Down-shop conductors shall be of the fully insulated shrouded

busbar type. The current collectors shall have renewable contact pieces. Festoon cables may be used for cross travel. A crane isolator, lockable in the 'Off' position and incorporating a warning lamp, illuminated when the supply is 'On', shall be provided at the bottom of the access ladder. A second isolator shall be provided at the control cubicle located on the crane platform.

All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, 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 conductors manufactured from high conductivity hard drawn copper. 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.

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. The Contractor shall supply all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and protection in case of power supply failure. All electrical equipment shall be fully tropicalised. Motors and switchgear shall be provided with anti-condensation heaters, which shall be energised when the crane is at rest, and suitable warning notices shall be provided.

3.13 EOT Crane for Tidal Control Gate Area with Tidal Control Gate Structure

An electrically operated overhead travelling crane / EOT crane of minimum SWL capacity twice the max. weight of equipment / component to be lifted. The EOT crane will have longitudinal movement to cover up to Tidal Control Gate and cross movement spanning Tidal Control Gates and Stop logs. This EOT will be designed for Lifting of Tidal Control Gates and stop logs from their positions during maintenance and

installation requirements. An approach platform will be constructed to facilitate loading and unloading of removed Tidal Control Gates into the vehicle. The EOT shall be provided with cabin operation facility including control panel, cables, maintenance platform, caged ladder and allied works for covering movements of EOT throughout Tidal Control Gate area.

General requirements:

All EOT Cranes shall be designed and constructed in accordance with IS:3177 /BS 2573 and shall comply with the requirements of BS 466: Class 2 medium-duty operation. The term 'crane' shall be deemed to include gantry rails, platform with handrails for maintenance use, down-shop conductors, end stops, holding-down bolts and all other items required for complete installation. Mechanisms shall be design in accordance with ISO 4301. The EOT crane shall be manufactured as per drawings and design approved by the Engineer.

The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that plates more than 20 mm 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.

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

All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100,000 hours. Electro-magnetic and 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.

Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS:2903 / BS:3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

Hoist rope shall be extra flexible, improved plough galvanised steel rope with well lubricated hemp core. The ropes shall conform to IS:2266. Rope drums shall be

grooved and shall be either cast iron or cast steel or welded steel conforming to IS:3177, BS:466 or relevant internationally approved standards.

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 and BS:721 or relevant internationally approved standards.

Cranes shall be prominently marked / inscribed with safe working load (SWL) on each side of the crane bridge girders readily legible. Crane hooks shall be fitted with safety latches and the hook block shall incorporate fully guarded rope sheaves. The maintenance platform shall be designed to provide safe access to the crane machinery and all high-level lighting and roof-mounted ventilation plant. Access to the platform shall be by fixed stairway from a convenient point in the concerned building.

The EOT Crane operation shall also be by control pendant from ground floor level.

EOT Crane shall be labeled or marked with the safe working load (SWL) and the purpose for which they are intended. The crane, and all other lifting equipment supplied shall be tested by the manufacturer at his works and test certificates shall be submitted by the Contractor.

Before EOT Cranes are put to use for any purpose whatsoever it shall be tested at site to lift and maintain a minimum test load of 125% of the safe working load. During this overload test each movement in turn shall be maneuvered and the EOT Crane shall sustain the load under full control. The Contractor shall provide the necessary test loads and shall carry out the tests in presence of engineer of the Contract, who will require to measure deflections and record other observations.

The maximum deflection under full load shall not exceed 1/900 of the span (as per IS:3177).

The test loads shall be removed from site by the Contractor after successful tests have been completed.

Use of equivalent standards of other countries or organisations may be permitted.

Suitable lifting slings, shackles, lifting beams, wire ropes, etc. shall be supplied by the Contractor at no extra cost to MCGM during entire period of testing, commissioning, operation and maintenance.

A trolley mounted moving grab shall be fixed on to the cross travel adjacent to the hoist mechanism. arrangement.

While designing the grab mechanism and the material of construction of grab, following factors should be taken in to consideration:-

- The components of grab mechanism will be subject to alternate drying and wetting during the course of operation.
- The grab will be operated in storm water severe environmental conditions like exposure to marine environment, natural tides and wave action, exposure to brackish and saline water

- The grab will be subjected to impact load during each downward movement
- The grab will be subjected to abrasion on account of concrete structures, debris and deposits.
- removal of deposits / large objects of about minimum 1000 kg per grab or volume equivalent to minimum 1 m³ of refused collectibles during one stroke / objects

Electrical requirements:

All movements shall be electrically powered and be suitable for operating with the hook fully loaded. Motors shall be of the quick-reversing type with electro-mechanical brakes suitable for the duties specified. All motors shall be TEFC with IP 55 enclosure designed for operation at 415 V +- 10%, 50 Hz +-5% Limit switches shall be incorporated to prevent excess travel, or over-hoisting and over-lowering of the crane hook. Facilities shall be provided for the accurate location of the hook by means of 'inching' all the motions.

Crane operation shall be from ground floor level by bridge-mounted pendant push-button controls. Controls shall be mechanically and electrically interlocked to prevent inadvertent operation of opposing motions. The pendant shall be supported independently of the electric cable and shall be arranged for extending for operation when necessary. Down-shop conductors shall be of the fully insulated shrouded busbar type. The current collectors shall have renewable contact pieces. Festoon cables may be used for cross travel. A crane isolator, lockable in the 'Off' position and incorporating a warning lamp, illuminated when the supply is 'On', shall be provided at the bottom of the access ladder. A second isolator shall be provided at the control cubicle located on the crane platform.

All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, 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 conductors manufactured from high conductivity hard drawn copper. 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.

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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. The Contractor shall supply all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and protection in case of power supply failure. All electrical equipment shall be fully tropicalised. Motors and switchgear shall be provided with anti-condensation heaters, which shall be energised when the crane is at rest, and suitable warning notices shall be provided.

3.14 Drainage Pump Set

A freestanding portable type submersible type non clog drainage pump set (1 working + 1 standby) shall be supplied for draining storm water from inlet and individual pump bay. Solid handling capacity shall be 100 mm.

The pump shall be capable of discharging minimum 20 m³/hr against a total head of 10m (min).

The pump set shall be complete with 20 meters of armored hose and 20 meters of submersible cable terminating in a plug along with lifting chain, guide pipe, duct foot bend arrangement.

3.15 Tidal Control (Mitre) Gates

General:

7 nos. gates each with a clear opening of 4 metres shall be provided in the position indicated on the drawings.

The top of Tidal Control Gate shall be at 28.00 m THD and the Sill level 22.80 m THD approximately.

The gates shall generally be constructed in accordance with the following United Facilities Guide Specification as issued by the US Corp of Engineers, Division 35 – Waterway and Marine Construction, Section 35 20 16.33 - Tidal Control Gates.

All payment and commercial aspects of this specification shall not be applicable.

Gate Performance:

The gates shall be designed to withstand the full on-seating pressure when the water level outside the gates is level with the top of the gates and the channel inside is empty.

The gates shall automatically open and close against a differential head of 200 mm. When closed the maximum leakage through the gates shall be 1.25 litres per minute

per meter of sealing perimeter. If necessary, hydraulic damping shall be provided to prevent the gate flutter. The gates shall be fitted with a means to lock them in an open position. Channels are to be provided for stop logs upstream and downstream of the gates to enable the gates to be isolated for maintenance and replacement. Sufficient stop logs to isolate one gate shall be provided. A means shall be provided for place and removing of the stop logs.

A roadway shall be provided to give access to the gates and shall be complete with all necessary hand railing etc.

3.16 Stop logs

The stop logs shall be wall mounted located in guide channels as required as per approved General arrangement drawing. The logs shall be constructed from steel reinforced rigid polyester-based urethane foam covered in a high tensile strength composite plastic or aluminium. The frame shall be fabricated from SS316. Sealing between logs shall be maintained by a neoprene strip overlaid by a strip of low friction plastic to facilitate log removal. Equivalent or superior technology for sealing between logs and frame is acceptable. Under normal operating conditions, the leakage rate shall not exceed 20 l/h for each meter of periphery.

3.17 Fire Fighting System

The system consists of pressurized, automatic internal fire hydrant system, sprinklers' system and external courtyard fire hydrant system. Technical specifications enclosed herewith shall be followed strictly so far as the workmanship is concerned.

The scope of work for firefighting includes but not limited to the following. The Contractor shall be deemed to have considered all such things so as to provide complete system as per requirements of the Chief Fire Officer and any inadvertent omission of anything in the Scope of Work will not entitle the contractor for extra claims.

- 1 Supply and install in position main pump and booster pump of required capacity and specifications for hydrant and sprinklers system, in the underground firefighting pump house.
- 2 Supply and provide and fix 200mm dia. carbon steel piping within the pump house for suction and delivery including all necessary fabricated or- flanged fittings like tapers, bends, tees etc as required and directed.
- 3 Supply and install C.I. double flanged valves like sluice valves, and non-return valves in the pump house and elsewhere in the system.
- 4 Supply and install pressure vessels / diaphragm type air vessels with air valve and pressure gauges with 15 mm dia. Brass check nut & capable of showing pressure reading from 0.0 to 15 Kg. and pressure switches on the pressure vessels / pump deliveries for start & stop pumps.
- 5 Supply and provide support the wet riser horizontally along the ceiling and or wall of the pump room by means of approved "Hot Dipped Galvanised" rods and angles after the approval of the sample. These hangers are fixed to the ceiling slab and or wall of pump room by dash fasteners.

- 6 Supply and provide and install tested flanged C. I. strainers of all required size.
- 7 Supply and provide and install tested flanged C. I. sluice valves of all required size.
- 8 Supply and provide and install tested flanged C. I. non-return valves of all required size.
- 9 Supply and provide the 150 dia. G.I. class C, wet riser through the space (fire duct) provided in the building up to the topmost floor.
- 10 Single ball acting air release valve with 25 mm G.M. stop valve.
- 11 Mild steel fabricated fire hydrant hose cabinet with glass front, suitable to accommodate 2 length of canvas hose of 50' (15 M) long and nozzle 2'3" x 2'0" x 1'0" size (70x60x30 cm) painted in 2 coats of post office red.
- 12 Supply and provide 65 mm dia x 15 m long 2 nos. Canvas hose pipe having 1 no. male instantaneous coupling with plunger locking arrangement wired on either ends and scrawled down type jet nozzle on either end.
- 13 Supply and provide G.M. branch pipe with G.M. nozzle and with 63 mm instantaneous type coupling.
- 14 Supply and provide drum type wall mounted 180 degree swiveling hose reel having 20 mm dia 30 m long best quality approved make armoured rubber hose pipe with 10 mm dia. outlet bronze jet nozzle and shut off cock on the outlet.
- 15 Supply and provide 65 mm dia twin hydrant valve oblique pattern with separate control, landing valve with companion flanges
- 16 Supply and provide Dry chemical powder type fire extinguisher of 5 kgs capacity.
- 17 Supply and provide fire buckets with stand etc. complete.
- 18 Supply and provide support to the riser by "U" bolts fixed to "Hot Dipped Galvanized" bracket as required.
- 19 Take the firefighting water main outside the pump room and run it below the ground level for providing courtyard hydrants as per the requirements/consultants drawing for external firefighting system.
- 20 Supply and provide 150 x 100 tees at every floor or landing with a slip-on flange Table 'D' welded to the 100mm dia branch of the tee with holes drilled to match the holes of the hydrant valve flange for fixing the valve.
- 21 Supply, provide and fix gun metal orifice plates to reduce pressure on hydrant valves up to 3.5 kg per sq.cm.
- 22 Supply and fix 65dia. gunmetal siamese twin hydrant valve to the 100 mm dia. of branch provided on each floor to the wet riser.
- 23 Supply, provide and fix 30 m long 20 mm dia. first aid hose reel of flexible rubber with shut off nozzle wound round a swivel drum at every floor above the hydrant valve and connecting one outlet of the twin hydrant to first aid hose.

24 Supply, provide and fix 2 lengths of 65 dia. 15 m long canvass hose with couplings adapter branch pipe and nozzle in a sheet metal box with lockable glass doors and painted in post office red colour at a location clearly visible on ground and every upper floor.

25 Supply, provide and fix oblique single hydrants to the hydrant stand posts for courtyard hydrants around the buildings

26 Supply, provide and fixing 25 dia. G.M. Drain valve at the foot of the wet riser and required length of 25 dia G.I. class C pipe to discharge into underground tank or in the storm drain.

27 Supply, provide and fixing spring loaded 4 Nos 65 dia tanker water/fire dept. breaching inlet with rubber caps near the compound wall and facing the road and connecting the same to the underground firefighting tank by 150 dia GI class C pipe discharging above water level.

28 Provide 50mm dia. G.I. class C pipe branch from the wet riser within the pump house to the U.G. tank along with 50mm dia sluice valve for testing purposes.

29 Provide electrical panel in the pump house for fire pump and stopping the booster pump when main pump has started.

30 Fixing 4 inlets with rubber caps to the 200mm dia. firewater ring main for connecting the mobile fire engine of the fire-fighting department at ground level with a check valve.

31 Providing installing testing and commissioning of 17-zone fire alarm panel.

32 Providing installing testing and commissioning of break glass unit on ground floor and each upper floor.

33 Providing installing testing and commissioning of dual tone electric hooter on ground and each upper floor.

34 Providing installing testing and commissioning of ISI marked copper armoured cable.

TECHNICAL SPECIFICATIONS

(A) FIRE HYDRANT SERVICE, EXTERNAL AND INTERNAL PIPE WORK

1. The layout of the hydrant system shall be as per TAC rules and as approved by the Chief fire officer, so as to achieve a minimum pressure of 3.2kgs/cm² at the highest /hydraulically remotest hydrant point in the building/complex. (A set of approved drawings must be submitted to CFO before commencement of work)

2) All pipes above ground/underground shall be mild steel galvanised, Heavy grade 'C' class conforming to IS :1239 (Part I) up to 150NB and carbon steel confirming to IS : 3589 (commercial quality) with minimum wall thickness (TW II or) 6mm for size 200 mm NB and above, as required by the local fire brigade authority and as per TAC regulations.

The contractor shall furnish manufacturer's certificates for all pipes used in the installation before commencement of fabrication and installation.

3) Mild steel conforming to IS : 1239 (Part II) heavy class up to 150 NB Fittings above 150 NB size shall be fabricated out of heavy class pipe with butt welded ends. Flanges shall be with thickness and other details as per ANSI and drilled to IS : 1538

Mitered bends in 200 NB, if required, shall be fabricated at site from pipes of same size (20% of shop joints and 100% of all field joints must be radiographed subject to conditions that total number of joints radiographed are 100 % or total joints and radiographic certificates must be submitted to the Engineer.)

4) Cast iron flanged Sluice/Gate Valves shall be provided in the hydrant mains and risers. The valves shall confirm to IS : 780 PN-1.6. The valves must bear ISI mark and hydraulically tested to pressure of 16 kg/cm² when installed. Shop tests shall be as per IS 780 PN-1.6. 'Body' tested to 25kgs/cm² and the valve seat to 16kgs/cm². All underground valves must be provided with brick masonry valve chambers with heavy type cast iron covers to facilitate maintenance and having an area of 1 sq.m. minimum.

5) All pipes shall be first cleaned, and wire brushed. The above ground pipes and fittings shall be given two coats of red primer and one coat of 'Red' paint as per TAC/Fire Authority regulations.

6) All underground pipes and fittings shall be coated and wrapped as per IS : 1021 and TAC regulations in the following manner :-

Thorough and complete cleaning of the pipe surface.

Priming by coal tar primer

Coating by coal tar primer

Inner wrapping with glass fibre

Second coating by coal tar enamel

Second wrapping with, glass fibre

Final coat of coal tar enamel

Outer wrap of kraft paper or equivalent

Test for coated pipes must be carried out. This test is a high voltage spark test using a testing machine to ensure that the coating and wrapping of pipes are done uniformly without any dry patch.

7) Both above ground and underground pipes shall be adequately/firmly supported at regular intervals as per standard brackets with suitable anchor fasteners, duly approved by owner / Fire Authority / TAC. In the case of underground pipes, brick masonry / PCC concrete supports as specified shall be provided at a distance not more than 2.5 to 3.00 meters apart depending upon the nature of soil in the area. The pipes laid underground shall be 1.00 m (top of pipeline) below ground level.

8) The entire pipework when completed is to be flushed with a pressurised water system. After flushing the installation, the same should be hydraulically tested to a pressure equivalent to 1.5 times the maximum working pressure for a period of two hours.

9) Hydrant Accessories such as G.M. Hydrant valve, Fire hoses with G.M. Coupling, Branch pipes with Nozzles, Hose Reels etc. shall be of approved make and conforming to relevant Indian Standards and requirements of TAC, and Fire Authority.

B) FIRE AUTHORITY REQUIREMENTS

1 Siamese Connection

The storage tank will be provided with 150 mm Fire Brigade (4Nos.) Connection to discharge at least 1800 litres of water per minute into the tank. This connection pipe shall be taken into the storage tank up to 150mm above the water level in the tank. The connection shall be fitted with a stop valve.

An overflow pipe of 200 mm dia. to be provided to discharge the overflowing water at a visible drain point.

2. Fire Brigade Connection

The Fire Brigade Connection shall be fitted with 4 Nos. of 65mm diameter instantaneous inlets at a suitable position at street level so located as to make inlets accessible.

C) FIRE PUMPS

- 1) Pump shall be provided with a pressure gauge on the delivery side between the pump and the non-return valve and a plate indicating the delivery head, capacity and the number of revolutions per minute and all other details, which the manufacturer has to provide as per relevant Indian Standards.
 - 2) Pump shall be capable of furnishing not less than 150% of rated capacity at a head of not less than 65% of the rated head. The shut off head shall not exceed 120% of rated head in the case of horizontal pumps. Such pumps shall be of TAC approved make.

D) SLUICE/GATE/CUT-OFF VALVES

These valves conforming to IS:780 PN-1.6 are necessary to obtain the best possible pressure at the seat of fire and also enable a portion of the installation to be isolated while full pressure is available throughout the remainder.

E) HYDRANTS

All hydrant outlets shall be situated 1M above ground/finished level conforming to following IS codes:

G.M Hydrant Valve 65mm (2½ inches) IS:5200
also known as landing valve.

65 mm G.M. Branch pipe with nozzle
and G.M. Hose couplings. IS:903

65mm Reinforced Rubber Lined (RRL) 1S:636
Type II A / Type A

20mm NB First Aid Hose (For Hose Reel) reinforced rubber hose pipe IS 884:

M.S. Fabricated Hose Cabinet/Box fabricated out of M.S 16 SWG Sheet Steel and 3mm thick glass panel for front door.

F) STAND POSTS

- 1) The stand posts on the external hydrant system shall be single headed with bend or tee as the case may be, shall be in 80 mm in dia. and painted Fire red and numbered for easy identification.
- 2) Only oblique type hydrant with outlet angled towards ground or floor shall be used. The hydrant coupling male and female shall be of instantaneous spring lock type and valves shall be of the screw down type. The hydrant head stand post shall be positioned at distances not less than 2M from the face of the building or edge of the plot to be protected
- 3) No building shall be deemed to be protected by a hydrant unless such hydrant is within 15 metres of the building.

G) GENERAL REQUIREMENTS

- 1) The Contractor at his own cost and charges shall provide all materials, tools, measuring tapes, scaffolding, labour, water and power, necessary for the completion of the whole work, in all respects.
- 2) The Contractor shall pay fees for testing the material as required by local regulations, if any.
- 3) The Contractor shall arrange from time to time, various inspections, permissions and obtain final completion certificate under the rules of the Chief Fire Officer, Brihanmumbai Municipal Corporation.
- 4) The welding will be by using D C Current through rectifier.

H) AUTOMATIC SPRINKLER SYSTEM

The design of the sprinkler system shall be as per TAC and as approved by the Chief Fire Officer. The classifications of the risks and spacing of sprinklers shall be in accordance with TAC. However (considering the fact there is no perfect barrier between the two areas), the contractor shall design the layout of sprinkler system under Ordinary Hazard category. A set of approved drawings must be submitted to clients before commencement of work.

All pipes used in the sprinkler system network shall be mild steel galvanised, heavy grade 'C' class conforming to IS : 1239 (Part I) upto 150 NB. The contractor shall provide screwed joints for all pipes upto and including 150 NB. The pipe work is to be supported firmly along-side the wall, below beams ceiling etc. by means of mild

steel structural/special type pipe supports to ensure even discharge of water from sprinklers in an emergency without any distortion. Screwed fittings should conform to IS : 1239 (Part II)/B.S. 1641. M.S. screwed flanges shall be provided for easy disconnection during maintenance. All screwed joints must be leakproof.

Sprinklers that will be used in the installation shall be quartzoid bulb type of approved make and listed by LPC of U.K. (formerly PCC/U.K.) FM/UL of U.S.A. or TAC of India as per IS : 9927/1981.

The owner will accord approval of sprinkler before installation. Special type of guards to protect the sprinklers from mechanical damage shall be fitted wherever required at no extra cost. The operating temperature of the bulb shall not exceed 155 degrees F (68 degrees C), (Red Bulb).

Sprinkler Alarm Valve also known as Installation Control Valve (ICV) shall be of Approved make and listed by LPC of U.K., FM/UL of USA or TAC. All the associated trims as required shall be provided to be able to carry out performance test periodically without operating the sprinkler head. The valve assembly shall include alarm and gong, sluice valve, drain and test valves pressure gauge below and above the ICV together with the associated fixtures and fittings.

Note : The building is not to insured and therefore TAC approval/certificate is not mandatory. However, stage wise approval/certificate of the hydrant and sprinkler system by the Chief Fire Officer of the Municipal Corporation of Brihan Mumbai is required.

The entire pipe work when completed is to be flushed with a pressurised water system after flushing the installation the same should be hydraulically tested to a working pressure equivalent to 1.5 times the maximum working pressure for a period of two hours.

(I) FIRE EXTINGUISHERS

Adequate number of dry chemical powder type fire extinguisher of 5 kgs capacity shall be provided in various units of the Storm Water Pumping Station as directed by CFO. It is anticipated that fire extinguishers would be required in (a) DG room (b) Main Electrical House and Office Block (c) Workshop and Store (d) Pump House and near (e) Diesel Tank .

3.18 Ventilation Arrangement

PUMP SUMP VENTILATION SYSTEM

The pump sums shall be properly ventilated by a system of blowers and piping, to maintain healthy working conditions by keeping the air fresh and respirable and by eliminating harmful and obnoxious dust, fumes, and other gases. Ventilation system shall be of sufficient capacity to maintain an adequate supply of uncontaminated air at all points inside the sump.

The Contractor shall, submit the complete layout and plan of ventilation system, duly backed with detailed calculations justifying the deployment of ventilation equipment and accessories proposed, including the capacity of blowers, their spacing, diameter of

pipes, etc. There shall be 1 working and 1 stand by blower which will deliver air to a common manifold from where individual piping has to be provided to each sump. The capacity of each blower shall be suitable to serve one pump sump at a time and shall be based on minimum ten air changes per hour for the sump volume. The pipe work shall be complete with all necessary valves and fittings to enable isolation of each sump and each blower.

Connecting pipe work shall be designed for a maximum velocity of air as 10 m/s. The pipe work shall be metallic suitable for very corrosive and aggressive environment near sea and shall be able to withstand the heat due to flow of air.

Air blowers shall be single stage blowers provided with impellers, drive motor, integral gearbox, lubrication and a cooling system, all mounted on a common baseplate. It shall be as per IS 4894:1987. Blowers shall be designed to give clean, dry and oil free discharge. Each blower shall be provided with a coupling guard and motor, and the whole assembly shall be mounted on a I baseplate. All blowers shall be dynamically trim balanced to IS 4894:1987. Blowers shall be suitable for outdoor installation in corrosive environment and shall be complete with all accessories like silencers, anti-vibratory pads etc.

Supply of all necessary electrical components, devices, equipment, controls panels etc together with cabling earthing provisions, etc shall be the responsibility of the Contractor. Interconnecting pipework shall be arranged to avoid low points which may trap water. Unavoidable low points shall be provided with drain cocks piped to waste.

BUILDING VENTILATION SYSTEM

Toilet block and Pantry area shall be provided with sufficient number of exhaust fans to ensure minimum ten air changes per hour. If required multiple exhaust fans shall be provided to meet the demand. The fans shall be suitable for very corrosive and aggressive environment near sea. Louvers, bird screen shall be provided for the fans as required.

3.19 Pressure Jetting System

The purpose of this system is to provide water jet cleaning facility for pump sumps, screens, silt pit in front of screens, areas behind and in front of Tidal Control Gates, platform around screen cleaning system etc. The system shall be independent of fire system.

The system shall comprise of

- RCC water storage tank of capacity of not less than 150 cu.m.
- 1 W + 1 S horizontal centrifugal pump each of capacity 50cu.m./hr @ 4 kg/sq.cm.
- 2 nos. Stand pipe near screen platform to cover various areas described above with the suitable hose and nozzle
- Connecting metallic piping and valves.

- Material of construction for various equipment required in connection with Pressure Jetting System shall be suitable for very corrosive and aggressive environment near sea.

3.20 Mechanical Equipment - Data Sheets

(TO BE FURNISHED BY THE BIDDER)

Refer Section 2G for datasheets.

3.21 LIST OF RECOMMENDED MANUFACTURERS / MAKES FOR MECHANICAL EQUIPMENT AND INSTRUMENTS

Sr.	Equipment	PREFERRED MAKES
1	Submersible Type Axial flow pumps	WILO / GRUNDFOS / KSB / Flygt / Nijhuis Pompen/Hasuh/ Ishigaki
2	6.6 kV HT Diesel Generating sets	Powerica / Global Power / Sterling & Wilson / Powergen / Sudhir Gensets
3	Diesel engines	MTU / Cummins / Caterpillar / Mitsubishi / Perkins / Volvo
4	Alternators	Stamford / TDPS / Marathon Electric
5	415 kV LT Auxiliary Diesel Generating set with AMF panel	Cummins / Kirloskar / Greaves
6	Day tanks and Fuel transfer system to DG sets	To be provided by respective DG set manufacturer
7	Sluice Gates	JASH / IVC / Hambaker / Orbinox / VAG / Jindal
8	Bar Screen	EVA / Huber / Head Works
9	Trash Rack	Jash / Huber
10	Stop logs	JASH / IVC
11	Tidal Control (Mitre) gates	MCGM approved manufacturer
12	EOT Crane / Gantry crane	Brady & Morris / Demag / Hercules / Electromech
13	Submersible dewatering pump / Other pumps	Grundfos, KSB, KBL
14	Fire fighting system	MCGM fire department approved Manufacturer
15	High pressure jet cleaning	MCGM approved manufacturer
16	Forced air ventilation system	MCGM approved manufacturer

All the equipment, to be supplied under this contract has to be from experienced manufacturer. The equipment of only those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar or higher capacity, shall be considered. The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following:

- 1) Demonstrate that the proposed makes are Superior / Equivalent to the approved makes.
- 2) Manufacturer involved in manufacture of specified equipment for at least 10 years before bid date.
- 3) At least 3 successful installations commissioned in last 10 years before bid date and satisfactorily operating for at least one year before bid date. End user certificate shall be provided for the same.

Manufacturer to provide full contact information for each reference as part of technical bid And the above qualities and requirements shall be demonstrated and evidenced by inspection of manufacturing units and successfully installed plants (at the End users plant/premises) for the equipment desired and successful operation and certification by the Employer Representative.

The Employer shall reserve the right to accept or reject the Bidder proposed makes of Equipment.

Section 2D

Technical Specifications for Electrical, Instrumentation and Automation Works

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SECTION 2D – ELECTRICAL SPECIFICATIONS

1 SCOPE OF ELECTRICAL WORKS

It is not the intent to specify herein all the details pertaining to the design, selection of material / equipment, procurement, manufacture, installation, testing and commissioning, however, the same shall be of high standards of engineering and shall comply to all currently applicable standards, regulations and safety codes.

The scope of electrical works starts from handling of power generated by 4 nos. (min.) of DG sets of required capacity as per design requirements of the Storm Water Pumping Station (for details refer Volume 2, Section 2C, Mechanical Specification of this tender document) and utilise the same for operation of 7 nos. 6.6 KV Storm Water submersible Pumps (for details refer Volume 2, Section 2C, Mechanical Specification of this tender document). In The scope essentially covers design, procurement, inspection at manufacturer's facility, supply, installation / erection, testing and commissioning of the entire Electrical system essentially comprising of HT switchgear, Auto synchronisation panel, NGR-NIS panel etc. as described elsewhere and as per design requirements of Storm Water Pumping Station at Mogra.

The scope of electrical works also includes obtaining and receiving of 415V power from the grid power supply agency (BEST/ADANI etc) including supply of 415V switchgear, cable laying, installation, testing and commissioning of the receiving station and switchgear. This power shall be used for LV electrical loads. All enabling works including liaisoning with supply agency, obtaining of LT power supply on behalf of MCGM shall be carried out by the Contractor. All charges, deposits etc. required for obtaining of LT power supply will be borne by the Contractor.

The scope of work for the bidder under this component of the scheme includes supply, erection, testing and commissioning of Electrical works for Mogra SWPS. The contractor shall carry out his work as per guidelines and specifications given in this tender document. The various Electrical items for which the contractor has to submit his technical proposal and price bids are given herein. The successful bidder has to submit General arrangement drawings, technical data sheets, engineering details and operating & maintenance manuals for all equipment and obtain approval of the Engineer prior to proceeding with manufacturing and supply.

A black-start DG of 415 V, of required capacity (minimum 63 kVA) along with full-fledged AMF (Auto Mains failure) panel, is also included in the contractor's scope and will be utilised in the event of trip out of BEST/ADANI etc. supply and when the main DGs are required to be started for operation of the main pumps.

Grid power for the purpose of operation of the main pumps is not envisaged for the following reasons:

The load would require supply at 22 kV wherein substantial investment would be necessary for arranging this supply.

The pumps will be only sparingly run. The load on the grid system would, therefore, be very small with respect to its capacity and required Maximum Demand (MD). Electricity consumption charges which are also governed by sanctioned MD (amongst other factors) would be unacceptably high in spite of low energy consumption.

The utility power supply is likely to be switched – off during heavy rains condition / flooding, when it is required most.

The scope also includes cabling, lighting and earthing for the entire installation. A tentative Electrical Load list is shown on Single Line Diagram enclosed. The H.P. ratings are to be decided by the contractor which shall be subject to Engineer's approval. The contractor shall work out the details based on his equipment's power consumption. The execution should take care of Electricity Board's requirement and other local authorities and site condition.

The Contractor shall be responsible to carry out Factory as well as Site Testing of Electrical Equipment & Panels as per approved QAP and as specified in the relevant standards. The contractor shall also responsible to carry out engineering up to Relay Coordination. The Contractor must ensure that calibrated test equipment having valid calibration test certificate from standard laboratories traceable to National Standards are used for measurement of parameters during testing.

It shall be the contractual responsibility of the contractor to obtain approval to drawings, designs, electrical installation and test certificates from Chief Electrical Inspector to Government (CEIG) and any other statutory bodies. All charges associated with these permissions for eg. Electricity generation charges etc. shall be borne by contractor.

Approvals from following authorities shall be obtained before electrical installations are charged and DG sets are commissioned:

Electrical Inspector

Chief Controller of Explosives (CCOE) for diesel storage facility
Maharashtra Pollution Control Board for chimney exhaust, DG acoustic etc.
Fire Fighting system approval by TAC / applicable statutory body.

Necessary official procedural support as well as technical assistance required in obtaining the approval shall be provided by the purchaser/engineer.

The major items of work for the electrical works will be as under:

- i) 6.6 kV Indoor, metal clad switchgear for pump house as per S.L.D, enclosed. 1 set of Cable Earthing Truck and Bus bar Earthing Truck with pre-warning facility is also included in the scope of supply.
- ii) 8 (7 nos. service + 1 no. spare) Nos. soft starters for 6.6 kV main storm water submersible pump motors (Section 2C, Volume 2). These shall be based on Flux Compensated Magnetic Amplifier (FCMA) principle Technology. Other technologies such as auto-transformer based or Liquid Rotor Starters etc. are not accepted. Soft Starters may be on the line side or neutral side of the motor, as per bidder's design of system
- iv) 4 nos. Neutral Grounding Resistors (NGRs) for grounding of neutral of 6.6 kV main DG sets of required power generating capacity as per design requirements of storm water pumping station with Neutral Isolator System (NIS) installed in closed room.
- v) 6.6 kV Indoor, metal clad switchgear for the DG system, as per S.L.D. enclosed
- vi) Auto synchronizing, Auto load sharing system for the DG sets.
- vii) 415 V switchgear at Pumping Station
- viii) 415 V switchgear for Aux. DG installation (for emergency loads)

- ix) 415 V Fire Fighting Panel
- x) 6.6./0.433 kV, 250 kVA dry type transformer
- xi) 6.6kV Cables for 6.6 kV power handling and distribution system
- xii) 6.6KV cable termination kits for above cables
- xiii) Automatic Power Factor Correction (APFC) equipment to improve the grid system P.F. to 0.995 lag. These shall be bus connected and shall correct the P.F. at PCC level.
- xiv) Local Push Button Control Stations for all equipment / motors as statutorily required.
- xv) 110V Sealed Maintenance free (SMF) Lead – Acid – battery of adequate AH capacity to cater to control circuit loads of 6.6 kV switchgear both at Pump House and DG installation, 6.6 kV soft starters as required, complete with Float-cum-Boost charger and DC Distribution Board.
- xvi) Uninterrupted Power Supply (UPS) system to cater to the requirements of PLC, SCADA system and instrumentation loads both at Pump House and DG installation. The UPS shall be sized to provide a margin of 25% over the calculated (design) load and shall provide 1 hour back up. Back-up batteries shall be SMF lead Acid type with adequate AH capacity.
- xvii) Complete automation system by way of PLC and SCADA shall be provided for :
 - i) Automatic, sequential and cyclical operation of all the main pumps.
 - ii) Automatic, sequential and cyclical operation of all the DG sets
 - iii) Periodic testing (exercising) of all the equipment
 - iv) Data logging & alarm generation for important parameters of the system.The system shall be provided with manual override facility. Manual override key shall be soft and shall be authorised by Plant in-charge with a password.
- xviii) CCTV System
- xix) LT power, control and instrumentation cables as required for the entire installation.
- xx) Earthing system in accordance with IS 3043, IE rules to provide equipment and personnel safety as well as clean earth system for instrumentation / signal earthing. As the pumping station installation will be constructed across the nalla, the earthing installation (earth pits) will have to provided upstream of the pumping station close to retaining wall.
- xxi) Lighting system: Both indoor and outdoor lighting covering lighting distribution boards, lighting panels, lighting fixtures, aviation lighting, JBs, lighting cables and RS conduit for exposed type installation.
- xxii) Cable Carrier system: Cables shall be laid in FRP cable trays to be installed in cable cellar, cable trenches or supported from wall or ceiling inside the building. Interplant

cabling shall be in built up RCC trenches with FRP cable trays mounted inside and with adequate walkways for personnel movement.

- xxiii) Lightning protection system shall be provided to a highest structure of the plant to cover entire area of the pumping station.
- xxiv) Safety equipment such as fire extinguishers, sand buckets, danger boards, shock treatment charts, first aid kits, rubber mats etc. as required statutorily and operationally.
- xxv) Fire Detection and Alarm system for electrical panels rooms and admin block

The list of minimum facilities shall be as specified in Volume 2, Section 2A – Detailed Scope of Works

An HV overhead line passes over the proposed Project site. Considering availability of project area and the Contractor's Plant layout, it may be necessary to have some pumping station installation for the Project below the OH line. It shall be Contractor's responsibility to :

- Liaise with the power supply authority and obtain No-Objection from them/ carry out necessary safety work such as providing safety mesh below OH line or as suggested by the power supply authority
- Obtain approval to such installation from Electrical Inspector, as required.

All costs towards this work shall be included by the Bidder in his Bid.

1.1 As BUILT DRAWINGS

After completion of manufacturing, installation and commissioning of all Electrical works mentioned above, prior to commencement of Operation and Maintenance period, the contractor shall prepare and submit to MCGM, five complete sets of As-built Drawings - two set will be on R.T.F. and remaining four will be on A1 size drawing paper with lamination; and one set of the drawings in soft form on the compact disc (CD). As-built Drawings are the Detailed Engineering Drawings showing the actual details according to which the Construction/Fabrication/Erection has been carried out. The contractor shall have to obtain approval of the As-built Drawings from MCGM.

2 TECHNICAL SPECIFICATIONS – SPECIFIC REQUIREMENTS FOR ELECTRICAL WORKS

2.1 GENERAL

This chapter details the specific requirements of electrical works provided for the plant.

This Technical Specification sets out the general standards for design, submission of drawings, materials, workmanship, inspection and testing, packing and shipment, storage, protection, erection at site, O & M manual, spares and tools etc. of components, equipment, accessories and the Facilities to be supplied by the Contractor. Mention of any specific Plant and Equipment does not necessarily imply that it is included in the Facilities.

All component parts of the Facilities shall, unless specified otherwise in the Particular Technical Specification (SECTION 3), comply with the provisions of this Standard Technical Specification. The Engineer of Contract shall have power to reject any Plant and Equipment which in his opinion is unsatisfactory or not in accordance with this Specification and such Plant and Equipment shall be replaced by the Contractor at no extra cost to the Buyer.

The names of the manufacturers proposed by the Contractor for incorporation in the Facilities for Equipment and accessories which are not covered in the list of approved makes shall be submitted by the Contractor together with technical data sheets, drawings, performance, capacities, certified test reports and other significant information including details of manufacturing facility shall be provided for consideration by the Engineer of Contract.

2.2 OPERATING VOLTAGES AND FREQUENCIES

a. MV System (In plant generation)

- Voltage: 6.6 kV nominal
- Frequency: 50 Hz
- Connection: 3 phase, 3 wire
- System Earthing Through Neutral Grounding Resistor (NGR), Non-effectively earthed

b. LV System for auxiliary equipment

- Voltage: 415 V nominal
- Frequency: 50 Hz
- Connection: 4 wire
- System Earthing: Solidly earthed
- 415V Maximum fault Level: As applicable

c. Control Voltage, Instrumentation Power supply, AC Control, lighting & Space heating

	AC Control & Instru, Power Supply	Lighting & Space heating
--	--------------------------------------	--------------------------

- | | | |
|---|------------|-------|
| - | Voltage: | 110 V |
| - | Phases: | 1 |
| - | Frequency: | 50 Hz |

- d. DC control voltage (for 6.6kV switchgear and 6.6 kV soft starters)
- Voltage: 110 V DC
 - Wires/Earthing 2 wire / unearthed

Note: All hardware (nuts, bolts, washers etc.) for panel fabrication, electrical installation shall be stainless steel SS 304 only. GI or Plated hardware is not acceptable. This requirement overrides all the references of GI / Plated hardware that might appear in general specifications elsewhere.

2.3 STANDARD SPECIFICATIONS

Where reference is made in this Specification to a Standard Specification the Plant and Equipment concerned shall comply with the latest / current edition of Standard Specification (six weeks before the date for the Submission of Bids unless otherwise stated in this Specification).

All Plant and Equipment supplied and workmanship performed in regard to which standard specifications have been issued by the International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC) shall be supplied and performed in accordance with such standard specification unless otherwise specified in this Specification or approved by the Engineer of Contract even though the standard specification is not referred to in this Specification.

Use of any alternative relevant authoritative internationally recognised equivalent reference standard at no extra cost to MCGM may be permitted provided the Contractor submits copies of specified and relevant standards, proof of previous suitable use for review and assessment of the Engineer at the stage of approval of designs and drawings. However, Engineer's decision in this regard shall be final and binding on the Contractor.

Where reference is made in this Specification to a manufacturer's products such reference shall be taken only as an indication of design and quality.

2.4 GENERAL REQUIREMENTS AND WORKMANSHIP

All Equipment and Accessories shall be new, manufactured with sound workmanship, shall be robust in design for a long and reliable operating life and suitable for intended application. Design features shall include the protection of equipment / accessories against damage caused by vermin, dirt, dust and dampness and to reducing risk of fire. All equipment and accessories and the pumping facility as a whole shall operate without undue vibrations and parts shall be designed to withstand maximum stresses by the most severe conditions of normal service. Wherever necessary, suitable anti-vibration measures shall be provided.

All Equipment and accessories shall be designed to permit safe operation and maintenance.

Unless otherwise specified, all items of Plant and Equipment shall be rated for continuous service at the specified duty conditions under the prevailing atmospheric and operational conditions on Site.

Where fitted bolts, spigots or other means for precise location are not employed in the assembly of the Plant and Equipment, locating dowels shall be fitted on completion of erection, to the satisfaction of the Engineer of Contract.

All components parts of the Plant and Equipment shall be strictly manufactured to close tolerances and thereby offer complete interchangeability of similar parts.

Unless otherwise specified, the Contractor shall make provision in accordance with his standard practice, for the prevention of corrosion and erosion in any part of his Plant. Such provision shall include the use of suitable materials, design of components and type of protective coatings and finishes.

All items of Plant and Equipment for which spare parts may be required shall have attached to them un-tarnishable metal plates clearly showing the manufacturer's name, serial numbers and basic information as to rating, etc, in sufficient detail to allow the unit or assembly to be identified in correspondence and when ordering parts.

Identification name and no. shall be prominently inscribed on each item of Plant and Equipment and its corresponding Control panel for reference in a manner to be approved by the Engineer of Contract. e.g. 'HT Switch Gear Pump No. 2'.

2.5 SUBMISSION OF DRAWINGS/DESIGN SHEETS/DATA SHEETS

2.5.1 Drawing Submission

The Contractor shall submit the following detailed drawings for review and approval of the Engineer of Contract.

- i) Detailed Design Calculation sheets for all mechanical works/equipment and accessories.
- ii) General arrangement drawings for all equipment to be supplied.
- iii) Technical Specification / data sheets showing rating, make, details and quantity of various components used in specific mechanical item / assembly.

Form of Drawings

Every drawing shall provide legible details and should have a title block in the right bottom corner showing following minimum details.

Client	MCGM
Consultant	
Contractor	
Equipment Manufacturer	
Equipment model and sl. No.	
Project Name & Location	
Drawing Title	
Location	
Drawing Number	

Revision Number	
Date of submission	
Designed by	
Date of approval	

2.5.2 Approval of Drawings/Documents/Technical Data Sheets

- a) Drawings, Technical data sheets and relevant submissions shall be approved by the Engineer prior to manufacturing.
- b) The review of design calculations and drawings shall be carried out only in respect of orientation and sizes of important members, general design principles and approach, adherence to requirements of the relevant IS or other statutory codes, compliance with the technical specifications given in the tender document, general or specific notes and with the requirements of good engineering practice. Check for any interference and taking remedial action is the responsibility of the contractor.
- c) Approval by the Engineer of Contract of the contractor's design or drawings shall not relieve the contractor of any of the contractual obligations or liabilities under the contract or his responsibilities for correctness of dimensions, material of construction, weights, quantities, design details, assembly fits, performance particulars and conformity of the supplies with the Indian statutory laws as may be applicable.
- d) Should it be required at any time after approval has been given by the Engineer of Contract that any drawings or documents submitted by the contractor are not consistent with any technical data, drawings or documents submitted or approved previously or substantially deviate from any major aspect of the contract, then such alterations or additions as may be deemed necessary by the Engineer of Contract shall be made therein by the contractor and the works carried out accordingly without any extra cost.
- e) The contractor shall make no revision after a design, drawing or documents is "approved for manufacturing" by the Engineer of Contract. In case the contractor desires to incorporate any amendments in an "approved" drawing, he shall re-submit the same for formal approval giving reason for the change required.
- f) Contractor shall be responsible for preparation and submission of drawings and designs complete in all respects as per the requirements of the technical specifications and the scope of work and as per sound engineering practices. Non compliance with this requirement may result in repeated revisions and resubmissions of drawings / designs resulting in time loss for which the Contractor shall be solely responsible.

2.5.3 Inspection and Testing during Manufacturing

- a) The Contractor shall submit Manufacturing and Testing / Inspection Quality Assurance Plan for each equipment / accessory prior to proceeding with the manufacturing, for approval of the Engineer.
- b) The Contractor shall offer each item of Plant, equipment and accessories for inspection, examination and witness testing at the manufacturing facility of the respective manufacturer. He shall inform the Engineer of Contract of the date when the Plant and Equipment will be ready for inspection and witness testing, well in advance.

- c) If the tests are beyond the resources of the manufacturer he shall make arrangements for these to be carried out elsewhere. Any variation / deviation of this requirement shall be agreed and confirmation in writing obtained from Engineer of Contract.
- d) The Contractor shall provide to the Engineer two unpriced copies of purchase orders / work orders for all Equipment and accessories including those manufactured at his own works. The orders shall indicate the Facilities for which the Equipment / accessory is required, state in details about the inspection and test requirements, material of construction and approved G.A. drawing reference, give sufficient information for ready identification and shall state that all items will be subject to witness inspection and performance test unless waived by the Engineer of Contract.
- e) Unless the witness testing is waived, in writing, all the item of Plant, Equipment and accessories shall be offered for witness testing and inspection to the Engineer. Witnessed testing may be waived on standard types of small Equipment / accessories or for small components used in the manufacture of Equipment and accessories made by the approved manufacturers. The Contractor should apply to the Engineer of Contract, when submitting orders, for witnessed testing to be waived on standard items of Plant and Equipment.
- f) The Contractor shall give reasonable notice to the Engineer of Contract of the date when each item of Plant and Equipment is ready for inspection and witnessed testing. Prior to calling for inspection / testing, the Contractor should carry out their internal inspection/ testing and should submit their internal test report for review of the Engineer.
- g) The Contractor shall carry out tests as stated in the current appropriate ISO, IEC or specified Standard, performance tests and such other tests as are necessary in the opinion of the Engineer of Contract, to determine that the Plant and Equipment comply with the Specification either under test conditions in the manufacturer's Facilities, on Site or elsewhere in the ordinary working.
- h) Four copies of all test certificates and performance curves etc. shall be supplied to the Engineer of Contract within two weeks of completion of any witnessed tests, or when witness tests are not required within two weeks of the manufacturer's tests or within two weeks of the instructions to waive witness tests being received with respect to type tests.
- i) On each test certificate sufficient information to enable the Engineer of Contract to issue a release certificate, including the contract number and details, shall be given for ready identification of the Plant and Equipment to which the certificate refers.
- j) Where tests and inspection have been completed to the Engineer of Contract's satisfaction, and when the test certificates, test results, performance curves etc., have been checked / verified, the Engineer of Contract will confirm acceptance in writing and the Plant and Equipment shall not be delivered until this Acceptance has been received.
- k) The Employer reserves the right to require the Contractor to meet any extra costs which are occasioned by failure of the Contractor to comply with the above testing and inspection requirements, including the provision of test certificates, curves, etc., or, which in the opinion of the Engineer of Contract, are due to insufficient care having been taken by the Contractor before presenting the Plant and Equipment for inspection or test. If unauthorised delivery has taken place the Contractor may be required to arrange for the Plant and Equipment to be returned to the manufacturer for inspection and/or witness testing by the Engineer of Contract at the Contractor's expense.
- l) All apparatus, instruments and connections required for the tests, measurement of parameters shall have been duly calibrated for accuracy not less than six months prior to the tests.

2.6 PROTECTION AND PACKING DURING SHIPMENT AND STORAGE AT SITE

All Plants, Equipment and accessories while shipment and till they are installed in intended position shall be adequately protected and packed in accordance with the approved standard. In addition the Plant and Equipment shall be so protected as to be safe from spoilage, damage and corrosion until it is installed and commissioned at site.

All the items of Plant and Equipment which are finished painted at the manufacturer's works such as switchboards, shall be suitably encased in wooden structure and individual equipment / accessory should be securely fixed to wooden frame using appropriate method for their protection during shipment.

Particular care shall be taken in the packing of electrical apparatus. It shall be packed separately in sealed polythene or similar approved bags (including liberal supply of desiccant) taking all precautions to exclude moisture.

Packing cases shall be strongly constructed using tongued and grooved boards with internal and external battens. Each packing case shall be durably marked with the Contract number and site address and such other markings as may be directed.

The Contractor shall make good to the satisfaction of the Engineer of Contract any deterioration of the protective coatings, damage to equipment / accessories or their components or shall arrange for replacement of equipment or accessories in case of damage beyond repair or in case of loss or theft which may occur during transportation, loading – unloading or during storage at site.

An area on site will be identified by the Contractor for storage of all equipment / accessories till the time of installation. The Contractor shall provide all facilities for safe and proper storage, as recommended by the manufacturers, with particular consideration given to temperature, rains, sunlight, wind and ground conditions. No equipment / accessories shall be stored directly on ground. Items shall be handled and stored in a manner that they are not subjected to excessive stresses and their protective coatings are not damaged.

2.7 CONTRACTOR'S EQUIPMENT, ENGINEERING PERSONAL AND LABOUR

The Contractor shall, at his own expense, provide all equipment, tools, meters, gauges, temporary accommodation, skilled and unskilled labour, required for the execution of supply, site inspection, erection / installation of individual equipment and of the Plant as a whole, covered by the Contract.

Suitable qualified and competent specialist personnel shall be employed for:

- (a) Incoming inspection of all equipment / accessories.
- (b) Installation / Erection of the Plant and Equipment and checking for its correctness.
- (c) The necessary liaison with the Engineer of Contract in respect to measurement of work, submission of day work sheets / Installation protocol etc.
- (d) Site testing of all equipment / accessories.
- (e) Commissioning of all equipment / accessories and the plant as a whole
- (f) The Contractor shall not remove any supervisory staff or skilled labour from the Site without the Engineer of Contract's prior approval.

2.8 INSPECTION AND TESTING AT SITE

When the Contractor is satisfied that all the Plant and Equipment supplied is erected and in good working order, he will be required to demonstrate to the Engineer of Contract the erection and operation of the installed Plant and Equipment.

The Plant and Equipment will be inspected to establish its performance in accordance with the approved technical data sheets and to ensure compliance with the Specification. In the event of any item of Plant and Equipment failing to meet the requirements of the Specification or the final workmanship being defective the Contractor shall take immediate remedial steps and rectify the deficiency to the satisfaction of the Engineer of Contract.

2.9 PROTECTION OF MATERIALS

All Plant and Equipment supplied to site shall be provided with adequate protection against corrosion, mechanical damage, deterioration, fire, loss of items, damages due to rains etc. All such Plant, Equipment, accessories or components may required to be returned to the manufacturer's works at the Contractor's expense for making good any damage or deterioration etc., which may have occurred, until the Plant and Equipment is given Operational Acceptance.. The Contractor shall submit his proposals for achieving this protection for the approval of the Engineer of Contract.

The Contractor shall make good to the satisfaction of the Engineer of Contract any deterioration of the protective coatings, paintwork, etc., which may occur during transportation, erection, Site testing, operation, etc., until the Plant and Equipment is given Operational Acceptance.

Finish painting of the Plant and Equipment at Site, as specified, shall be carried out before the Plant and Equipment is given Operational Acceptance.

All parts which are not epoxy painted shall be hot dip galvanized. Hot dipped galvanizing shall be carried out in accordance with BS 729 with a deposition rate of at least 610 g/m². After galvanising all parts shall be passivated to minimise discolouration. All fixing bolts, washers, nuts and other items for supports and fixings shall be spun galvanised.

2.10 OPERATION AND MAINTENANCE MANUALS

The contractor shall submit 5 copies of operating instructions and maintenance manual of individual equipment / accessories to the Engineer-in-charge at the time of delivery at site.

Information supplied by the manufacturers employed by the contractor shall be coordinated into a comprehensive manual. The instruction manual shall describe the installation procedure as a whole and shall give a step wise instructions for any operation likely to be carried out during the life of each item of the plant including the erection, commissioning, testing, operation maintenance, dismantling and repair.

The manual shall include, but be limited to the following:

- Where applicable, fault location charts to facilitate tracing the cause of malfunction or breakdown.
- A section dealing with procedures for ordering spares.
- Technical Data sheets Specifications of equipment, General arrangement drawings,
- Schedule of preventive, maintenance, calibration and repair instructions.
- Parts list and spare parts recommendations

- Safety precautions to be taken while handling different units and First aid instructions
- Do's and don'ts for equipment operation. Operator's attention shall be drawn to all operations considered to be dangerous or likely to cause damage to the plant.
- A complete list of recommended lubricants, oils and their charts.

2.11 SPARES

Spares of individual equipment and accessories shall be manufactured as per specifications to strict limits of accuracy and shall be readily interchangeable with the parts they replace. The Contractor shall prepare a list of commissioning spares and regular spares required for individual equipment and submit it to the engineer for his approval. He shall not allow them to be sent by suppliers direct to Site. The Engineer of Contract may require to inspect the spares and packaging before dispatch.

Spares shall be packed and well protected for long term storage in accordance with ISO Guide 41. Associated Electrical components / equipment shall be sealed in polythene or similar bags with a liberal supply of desiccant. Each package shall have attached to it an embossed metal plate giving information for identification. This shall include the manufacturer's name and reference description as shown on the approved drawings.

The packages of items of spares shall be collected together by the Contractor into consignments of reasonable size and then packed in secure cases each of which shall contain a contents list. Each case shall be durably marked with the contract number and Site address and shall be sent to Site after detailed instructions for despatch have been received from the Engineer of Contract.

2.12 SPECIAL TOOLS

- (i) The Bidder shall arrange and use all kind of special tools and tackles as required during installation / erection and commissioning of all the equipment, accessories and plant on his own.
- (ii) The Bidder shall prepare recommendation list and separately price all special tools necessary for the proper maintenance of the Plant and Equipment. The Engineer of Contract will choose which tools shall be purchased and payment will be assessed according to the itemised prices. These tools shall not be used for the purposes of erecting the Facilities.
- (iii) The Engineer of Contract may require to inspect the tools and packaging before despatch and the Contractor shall hold them and not allow them to be sent by suppliers direct to Site.

3 6.6KV METAL ENCLOSED SWITCHGEAR

3.1 APPLICABLE STANDARDS

The switchgear and its components shall conform to the latest applicable BIS standards specified below or equivalent standards. In case of conflict between standards and this specification, this specification shall govern.

Code No.	Title
IS 13118 / BS 5311 / IEC 62271-100	Circuit Breakers
IS 3427 / BSEN60298 / IEC62271 – 1 & 200	High Voltage Switchgear & Control gear – Common Specifications, AC Metal Enclosed switchgear and Control gear for rated voltage above 1 KV upto and including 52 KV
IS 2705 / BS 7626	Current Transformers
IS 3156/BS 7625/IEC 186	Voltage Transformers
IS 5578, 11353	Arrangement for Switchgear Busbars, Main Connections and Auxiliary wiring
IS 2544 / BS 3297 / IEC 273	Busbar Support insulators
IS 13947 (Part 1) / IEC 947-1 / BSEN 60529	Degree of Protection
IS 3231, 3842 / BS 142 / IEC 255	Electrical Relays for Power system protection
IS 1248 / BS 89 / IEC 51	Electrical Indicating Instruments
IS 9385 / BS 2692 / IEC 282	High Voltage Fuses
IS 722, 8530 / BS 5685 / IEC 145, 211	AC Electricity Meters
IS 613	Specification for copper rods and bars for electrical purposes
IS 6005 / BS 3189	Code of practice for phosphating iron and steel
IS 9920 / IEC 129, 265 & 298	Alternating current Switches for voltages above 1000 V
IS 13703 / BS 136 2 / IEC 269	Low voltage fuses
IS 3452 / BS 3676	Toggle switches
IS 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
IS6875/BSEN 60947/IEC 947	Control switches

Internal Arc Classification

The switchgear shall be Type Tested for Internal Arc Classification IAC AFLR according to IEC 62271-200 where

- IAC represents Internal Arc Class
- A (for type of accessibility) for authorized personnel only
- F for Front
- L for Lateral and
- R for Rear side

Further, IAC rating shall be 26.24 KA for 1.0 sec.

Where hot gases exhaust flaps are provided in the design, the manufacturer shall spell out requirement of Top clearance with respect to ceiling

Where hot gases are handled by a duct in the design, the same shall be taken outside the switchgear installation room.

Arc Flash Analysis

Arc Flash analysis shall be carried out according to IEEE 1584 titled "Guide to Performing Arc Flash Calculations". Prerequisite for this analysis will be Protective Relays Coordination study which establishes relay operation times vis-à-vis fault current magnitude and hence available arc energy. Both Protective Relay Coordination and Arc Flash analysis shall be carried out with specific-designed, established software.

Based on Incident Energy in cal/cm² obtained and Hazard Risk Category viz. 0, 1, 2, 3, 4 or Dangerous

- Appropriate clothing such as Arc-rated FR shirt & pant, Arc flash suit
- Leather gloves, Arc-rated gloves
- Leather work shoes
- Safety glasses, electrically rated hard hat with hood and face shield, hearing protection

PPE (Personal Protection Equipment) shall be provided as per IEEE 1584. At least one (1) set of appropriate PPE shall be provided for the site installation.

3.2 CONSTRUCTIONAL FEATURES

- A. Metal clad switchgear and control gear shall comprise metal enclosed switchgear and control gear in which components are arranged in separate compartments with metal enclosures intended to be earthed. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits.

The metal clad switchgear and control gear shall have separate compartments for the following components:

- i. Each set of busbars
- ii. Current transformers
- iii. Voltage transformers on incomer side
- iv. Each main switching device
- v. Cable chambers suitable for heat shrinkable type cable
- vi. Metering and relaying devices.

- B. Degrees of Protection:

Protection against approach to live parts or contact with internal moving parts not less than IP4X class for all the above compartments.

- C. Switchgear shall comprise indoor, metal clad, Draw out type Vacuum circuit breaker. The circuit breaker shall be fully horizontally draw out type. The circuit breaker shall have distinct service and test positions. In the test position the circuit breakers shall be

capable of being tested for operation without energizing the power circuits. Four normally open auxiliary contacts shall be provided for each of the service and test limit position switches.

- D. The test position should preferably be obtained without the need to disconnect normal control connections and use of extension cords for testing.
- E. The switchgear shall fully house the breaker both in the service position as well as in the test position
- F. Switchgear shall be dust, moisture and vermin-proof.
- G. Separate removable gland plates with minimum thickness of 3 mm shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.
- H. All doors, panels, removable covers shall be gasketed all around with neoprene gaskets. All louvers shall have screens and filters. Vent openings shall be covered by fine mesh on the vertical face. The screens and grills shall be made of either brass or galvanized iron wire mesh.
- I. Metal clad unit shall comprise rigid welded structural frame enclosed completely by metal sheets, minimum 2.5 mm thick (hot rolled) or 2.0 mm thick (cold rolled), smooth finished, leveled and free from flaws.
- J. The current transformers shall be mounted on the fixed portion of the switchgear and not on the breaker truck.
- K. Each switchgear cubicle shall be fitted with a label in the front and rear of the cubicle. Each switchgear shall also be fitted with label indicating the switchgear designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.
- L. Painting
 - i. All sheet steelwork shall be phosphated in accordance with the following procedure and in accordance with relevant standards for phosphating iron and steel.
 - ii. Oil, grease and dirt shall be thoroughly removed by emulsion cleaning.
 - iii. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
 - iv. After phosphating, thorough rinsing shall be carried out with clean water, followed by final rinsing with dilute dichromate solution and oven drying.
 - v. The phosphate coating shall be sealed by the application of two coats of primer suitable for finishing by powder coating.
 - vi. After application of the primer, the fabricated sheet steel work shall be subject to epoxy based powder coating. Shade of powder coating is subject to approval by the engineer.
 - vii. The final finished thickness of the coating on steel shall not be less than 100 microns, and shall not be more than 150 microns.
- M. Structure, buses and control wiring troughs shall be so designed and arranged to make future extensions readily feasible.

N. Instruments, relays and control devices shall be mounted flush on hinged door of the metering compartment located in the front portion of cubicle. Panel door shall be supported by strong hinges and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts. All auxiliary relays not requiring manual resetting will be mounted inside the L.T. compartment.

O. Safety Interlocks

Switchgear shall be provided with following interlocks:

- i. Operation of an isolator shall not be possible unless the associated circuit breaker is in the open position.
- ii. Compartment door of a breaker or an isolator shall not open unless the associated breaker or an isolator is in open position.
- iii. Caution name plate, 'Caution Live Terminals' shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incoming terminals of main isolators.
- iv. Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the exposed live parts when the breaker is withdrawn.

Main Busbars

- i. Main busbars shall be of electrolytic grade **copper alloy** of high conductivity and non-segregated type.
- ii. Busbars shall be located in air insulated enclosures and segregated from all other compartments of the cubicle. Direct access or accidental contact with busbars and primary connections shall not be possible. To provide a seal between adjacent cubicles, busbars shall be taken through seal-off bushings or insulating pads.
- iii. All busbars joints shall be thoroughly cleaned and anti-oxide grease shall be applied. Plain and spring washers shall be provided to ensure good contacts at the joints and taps. Wherever aluminium to copper connections are required, suitable bimetallic connectors or clamps shall be used.
- iv. Busbars shall be rated in accordance with the service conditions and the rated continuous and short time current ratings specified in the Data sheet / SLD. Maximum temperature of the busbars and busbar connections, under operating conditions, when carrying rated normal current at rated frequency shall not exceed 85 deg. C.
- v. Busbars shall be adequately supported on insulators, to withstand dynamic stresses due to short circuit current. Busbar support insulators shall conform to relevant standards.
- vi. The busbar clearances in air shall be suitable for the short circuit levels.
- vii. Busbars shall not be painted and all performance characteristics specified shall be obtained with unpainted busbars.
- viii. Busbars shall be **fully insulated** for highest system voltage of 7.2 kV with heat shrinkable sleeves.

3.3 CIRCUIT BREAKERS

General

- i. Circuit breakers shall be VCB type. These shall conform to relevant standards specified and shall be of draw out type. Circuit breakers shall comprise three

- separate identical single pole units operated through a common shaft by the operating mechanism.
- ii. Circuit breakers shall be suitable for switching duty of transformers whose capacities are furnished in the single line diagram.
 - iii. Isolating plugs and sockets for power as well as control circuits shall be of robust design and fully self-aligning. Plugs and sockets for power circuits shall be silver faced and shall be insulated with PVC or other insulating material shrouds.
 - iv. The circuit breakers shall be complete with surge arrestors to provide protection to the equipment controlled by the breaker, against switching surges. The surge arrestors shall be 'rotating machine class type' suitable for use with motors.
 - v. Breaker internal wiring up to the plug shall be similar for all breakers.

A. Operating Mechanism

- i. Circuit breaker shall be power operated, by a motor charged spring operated mechanism. Main poles of the breakers shall be such that unless otherwise specified, the maximum difference between instants of contacts touching during closing shall not exceed half cycle of rated frequency.
- ii. Operating mechanism shall be provided with non-pumping feature, electrically and mechanically. Electrical anti-pumping feature shall be obtained by means of an auxiliary relay.
- iii. Main poles of the breaker shall operate simultaneously. There shall be no objectionable rebound and the mechanism shall not require any critical adjustment. It shall be strong, rigid, positive and fast in operation.
- iv. Mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and will not cause tripping or closing operation of the power operated closing devices. When the circuit breaker is already closed, failure of any auxiliary spring shall not cause damage to the circuit breaker or endanger the operator.
- v. A mechanical indicator shall be provided to show open and closed positions of breaker. It shall be located in a position where it will be visible to the operator standing on the front of the switchgear with cubicle door closed.
- vi. The closing coil shall operate correctly at all values of voltage between 80 % and 110 % of the rated voltage. A shunt trip shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and all values of supply voltage between 50 % and 110 % of rated voltage.
- vii. Mechanical trip and close devices shall be provided for manual operation of the breaker. Access to mechanical closing device shall be only after opening the cubicle door. However, the mechanical trip device shall be brought out to the front of the cubicle door.
- viii. Working parts of the mechanism shall be of corrosion resisting material. Bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned and locked to prevent loosening or changing adjustment with repeated operation of the breaker.
- ix. Auxiliary switches mounted on the fixed portion of the cubicles and directly operated from the breaker operating mechanism on each breaker having 8 'NO' and 8 'NC' potential-free contacts rated for 10 amps. 240V AC and 10 amp (inductive breaking) 110 V DC shall be provided. The contacts shall be in addition to those utilised in the control circuit of each breaker and shall be exclusively meant for the Purchaser's use in external interlocks and controls.

B. Spring Operated Mechanism

- i. Spring operated mechanism, shall be complete with motor, opening spring, closing spring with limit switch for automatic charging and all necessary accessories to make the mechanism a complete operating unit.
- ii. As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply to the motor, at least one open- close - open operation of the circuit breaker shall be possible.
- iii. Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring.
- iv. Closing action of the circuit breaker shall compress the opening spring ready for tripping.
- v. When closing springs are discharged, after closing a breaker, closing springs shall automatically be charged for the next operation.
- vi. Motor shall be such that it requires only about 30 sec. for fully charging the closing spring. Motors shall be rated for or 240V AC and shall operate satisfactorily at all values of voltage between 90 % to 110 % of rated voltage.
- vii. Mechanical indicators to indicate charged and discharged condition of spring shall be provided.

C. Operating Mechanism Control

- i. The closing and tripping control shall be by a control switch mounted on the cubicle door.
- ii. The mechanical trip and close devices shall be provided on the breakers in addition to above.

3.4 CUBICLE ACCESSORIES AND WIRING

Cubicle accessories and wiring shall include the following:

- i. Switchgear shall be supplied completely wired internally upto equipment and terminal blocks and ready for external cable connections at the terminal blocks. Inner panel wiring between cubicles of same switchgear shall be provided.
- ii. All auxiliary wiring shall be carried out with 650 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 mm².
- iii. Terminal blocks shall be of stud type, 650 grade, 10 amps, rated complete with insulated barriers. Terminal blocks for CTs and VTs shall be provided with test links and isolating facilities.
- iv. All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.
- v. All HT, LT and control cables should be FRLS and lugs should be ring type.

Meters

- i. Accuracy class for indicating instruments shall be 1.0. Instruments shall be 110 mm square with minimum 90° scale for flush mounting with only flanges projecting.
- ii. Electronic Multifunction meters (MFM) shall be provided with following minimum display:
 - Phase Currents
 - Line Voltages
 - Frequency
 - kW, kVA & kVAr with maximum demand in kVA

- P.F.
- KWH

These shall be complete with RS 485 communication facility for communication with plant SCADA system.

Relays

- i. Relays shall be suitable for flush mounting with only flanges projecting.
- ii. All protective relays shall be **Numerical** type, in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose. All auxiliary relays and timers shall be supplied in non-draw-out cases. Externally operated hand reset flag indicators shall be provided for all alarm auxiliary relays and lockout relays. Timers shall be of electromagnetic or electronic type only.

Selector Switches, Push Buttons, Indicating Lamps

- i. Control and instrument switches shall be rotary type provided with escutcheon plates clearly marked to show operating position and suitable for semi flush mounting with only switch front plate and operating handle projecting out.
- ii. Breaker control switches shall be pistol grip black and selector switches shall be oval or knob and black. Breaker control switches shall be three position spring return to neutral type. Instrument selector switches shall be of the maintained stay-put type. Contacts of the switches shall be spring assisted and contact faces shall be with rivets of pure silver. The contact ratings shall be adequate to meet the requirements of circuit capacity in which they are used.
- iii. All push buttons shall have two normally open and two normally closed contacts unless otherwise. The contacts shall be able to make and carry 5 A at 110V DC and shall be capable of breaking 1 A inductive load at 110V DC. They shall be provided with inscription plates engraved with their functions.
- iv. Indicating lamps shall be panel-mounting LED type, 2.5 watts with appropriate coloured lenses.
- v. Provision shall be made for receiving, distributing, isolating and protecting of auxiliary D.C. and A.C. supplies for controls, space heating, etc. The MCB ratings shall be so chosen as to ensure selective clearance of sub circuit faults.
- vi. Fuses shall be HRC cartridge type mounted on plug in type fuse base
- vii. The D.C. and A.C. auxiliary supply shall be distributed inside the switchgear with necessary isolating arrangements at the point of entry and with sub-circuit MCBs as required.

3.5 CABLE TERMINATION COMPARTMENT

- i. Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring.
- ii. Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper and of solderless crimping type.
- iii. All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc., shall be supplied. 6.6 kV cable terminations shall be with Raychem or approved equivalent make heat shrinkable type cable termination kit complete with single compression Brass glands. Direct entry of cables without brass glands is not acceptable.

3.6 INSTRUMENT TRANSFORMERS

- i. The current transformers and voltage transformers shall conform to the requirements stipulated in relevant standards specified.
- ii. The CTs and VTs shall be of cast resin type (insulation Class 'E') and shall be able to withstand the thermal and mechanical stress resulting from the maximum short circuit and momentary current ratings of the switchgear. These shall be completely encapsulated.
- iii. CTs shall have polarity marks indelibly marked on each transformer and at the associated terminal block. Facility shall be provided for short circuiting and earthing the CT secondary at the terminal blocks.
- iv. VTs shall be protected on their primary sides by current limiting HRC fuses with interrupting ratings corresponding to breaker rating and on secondary side with MCB's. Provision shall be made such that the primary fuses can be handled only in the de-energized position.

3.7 MISCELLANEOUS ACCESSORIES

- i. Space heaters of adequate capacity shall be provided inside each panel heater to prevent moisture condensation within the enclosure. The space heater shall be suitable for 240V, 1 ph, 50 Hz supply and complete with MCB for isolation purpose and thermostat to cut off heater at 45° C.
- ii. Each switchgear panel shall be provided with 240 Volts, 1 phase, 50 Hz, 5 amps. 3 pin receptacle with MCB located at a convenient position.
- iii. An 20 W CFL/F.T.L. interior illuminating lamp together with operating door switch and protective fuse shall be provided.

3.8 ANNUNCIATORS

Facia annunciators, suitable for operation on 110V DC shall be provided. Facia annunciators shall be:

- i. Equipped with 'Sound Cancel', 'Acknowledge' and 'Reset' push buttons common to annunciators on all switchgear aligned together and a 'Lamp test' push button for each annunciator on individual panels.
- ii. Provided with two lamps connected in parallel on each fascia window with series resistors
- iii. Suitable for normally open indicating contacts of either 'hand' or 'self' reset type
- iv. Suitable for annunciating subsequent faults with the specified sequence, immediately after acknowledging the previous fault
- v. Facia Window of minimum size of 35 mm x 50 mm

3.9 TESTS

The following tests shall be conducted at Manufacturer's works:

All routine tests shall be conducted in presence of the Purchaser / Consultant, as follows.

- a) Visual Inspection, GA check, Dimension check, Bill of Material check.
- b) Functional Test
- c) Primary current Injection Test
- d) Secondary Injection Test
- e) Interchangeability of Breaker

- f) High Voltage Test on power and control circuit
- g) Insulation Resistance Test (Before and After HV)
- h) Routine tests on one sample breaker – including limits of operation of closing and tripping coils, closing and opening times etc.

Site Testing

This is detailed under Section “Installation & Commissioning”

4 6.6/0.433KV DISTRIBUTION TRANSFORMER

4.1 SCOPE

The scope includes design/engineering, manufacture, testing and supply of resin cast dry type transformer of rating 250 KVA, 6.6 kV / 415V, 50 Hz and conforming to Energy Efficiency Level 2 as per IS 1130 with required spares and accessories, as per the technical specification. The efficiency and hence the losses shall be corresponding to Energy Efficiency Level 2 as specified in IS 1180 : 2014.

4.2 CODES AND STANDARDS

The design, manufacture and performance of equipment shall comply with all currently applicable statutes, regulations and safety codes.

Except where modified by this specification, wherever applicable all material and equipment's shall conform to the requirements of latest Indian Electricity Rule (IER) and below given standards, including all amendments.

Table 4:1 Codes and Standards for Transformer

Description	Standard
Dry type transformer	IS 11171 & IS 2026
Current transformer (PS class)	IS 2705
Degree of Ingress Protection for control gear	IS 12063
Bushing for Alternating voltage above 1000V	IS 2099
Thermal Evaluation & Classification of Electrical Insulation	IS 1271
Fittings and accessories	IS 3639
Measurement of transformer and reactor sound levels	IEC 60076-10 OR NEMA TR-1

4.3 CONSTRUCTIONAL FEATURES

4.3.1 General Requirements

The dry type cast resin transformers shall be AN (Air Natural) cooled. All material used shall be new, best quality and of the most suitable class for working conditions as per the tender technical specification. The material shall withstand the outdoor atmospheric conditions, overloads, over excitation and short circuits as per above standards without distortion, deterioration and the setting-up of undue stress in any part.

Nuts, bolts and pins shall be provided with lock washers or locknuts.

4.3.2 Core

- a) Transformer design shall be core type. The core shall be made out of high grade, non-ageing, low loss cold-rolled grain oriented (CRGO) silicon steel laminations. The core shall be painted and insulated with suitable resin to protect it against corrosion. The lamination shall be free from burrs and sharp projections.
- b) The yoke laminations shall be interleaved and carefully assembled to avoid air-

- gaps in the magnetic circuit. The core shall be earthed as per the relevant standards.
- c) The insulation structure in between core to bolts and core to clamp plates shall withstand a minimum voltage of 2500 V for one minute.
 - d) All steel sections used for supporting the core shall be free from burrs.
 - e) The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure.
 - f) The assembled core with all the clamping structures shall be free from deformation and shall withstand the vibrations during operations.
 - g) The core clamping structure shall be designed to minimize eddy current losses.

4.3.3 Windings

- a) The Cu-ETP grade copper conductor shall be used for transformer HV and LV windings.
The design and arrangement of the windings and their insulation shall be such as to ensure uniform distribution of the voltage surges among all the coils of the windings.
- b) The windings shall be provided with Class-F epoxy resin cast insulation. The insulation shall have high tensile and dielectric strength. Enough measures shall be taken during casting to avoid the void formation, cracking and crazing etc. of the cast coils.
- c) Both HV and LV windings of each phase shall be separately cast on rigid tabular coil co- axially arranged under vacuum in to moulds. The epoxy resin insulation system shall be fibre glass strengthened.
- d) The resin used for winding insulation shall be non-hygroscopic to prevent the penetration of moisture into windings. It should be possible to energize the transformer without pre-drying even after a long period of service interruption. The resin used shall be non-inflammable, self-extinguishing, void free and suitable for tropical climate with 100% relative humidity. In the case of windings provided with taps, the inter-turn insulation of tapped windings shall be reinforced to obtain uniform stress distribution.
- e) The transformer shall be able to withstand short circuits as well as switching and lightning/ atmospheric impulse voltages as specified in the IS 11171 Standard. The leads and connections shall be mechanically strong and adequately brazed to withstand short circuit forces and transportation shocks.

4.3.4 Core and Coil Assembly

The cast coils are inserted on to the core limbs. The resin cast spacer blocks, end blocks and separators shall be used as required.

4.3.5 Earthing

Single point earthing shall be used for magnetic circuit. The frame work and clamping arrangements of core and coil shall be securely earthed by copper strip connection to the main frame and enclosure. Two earthing terminals suitable for 75x10 mm GI strip shall be provided on the frame for enclosure earthing.

4.3.6 Tapping

Off circuit tap changing link shall be provided with total tapping range of +10% to -10% in steps of 2.5%. The tapings shall be on high voltage side. The transformer shall be capable of delivering its rated output at any tap position without damage.

4.3.7 Terminal box arrangement

- a) The HV side termination facility of the transformer shall be designed for connecting 6.6 kV XLPE insulated armoured cable terminated in crimping type lugs and heat shrinkable sleeves or pre-moulded cast resin push on type terminations. Suitable undrilled gland plate shall be provided for terminating HV cables. HV terminals shall be extended upto the cable terminals and the bus bars shall be located at a convenient height. The cable entry shall be from the bottom. Preferably the bus-bars shall be supported by the supporting insulators from the top frame of the enclosure. The winding delta formation of HV side shall be in supplier's scope.
- b) The LV side terminals and the LV termination box of transformers shall be suitable for sandwich 415 V XLPE insulated cable. The winding star formation on LV side shall be in supplier's scope.
- c) The LV neutral terminal of the star connected winding shall be brought out at two separate insulated terminals. One neutral terminal shall be provided by side of the phase terminals for connecting neutral to bus-duct neutral cable in the LV termination box.
Second neutral terminal shall be provided to facilitate the earth conductor down to the ground level. The terminal shall be suitable for connecting two numbers of earth conductors (75 mm x 10 mm GI) for neutral earth connection with two separate earthing pads.

4.3.8 Support Insulators

- a) Support insulators shall be designed and tested to comply with the applicable standards.
- b) HV terminals rated for minimum current 400 A shall have non ferrous and non-magnetic flanges and hardware.
- c) Air clearance and creepage distances shall be maintained as per the relevant standard.
- d) Preferably the material for support insulators shall be porcelain or epoxy resin case.

4.3.9 Temperature sensor & winding temperature indicators (WTI)

- a) Temperature sensors: Two (2) numbers, reputed make simplex type (Platinum) PT 100 shall be provided in each phase at suitable place for measuring hot spot temperature.
- b) A multi channel digital winding temperature indicator shall be provided to display the temperature of the windings.
- c) The indicating instrument shall be provided with four adjustable electrically independent ungrounded contacts brought out to separate terminals for winding temperature alarm and trip. The WTI shall be compatible to 110 V DC and 230 V, 50 Hz, AC auxiliary supplies.
- d) WTI scanner shall have remote PC (personal computer) communication facility.

4.4 ENCLOSURE FOR TRANSFORMER

- a) The core and coil assembly shall have CRCA sheet steel MS enclosure. The purpose of having the enclosure is to provide safety from live parts, protect and make the equipment suitable for indoor conditions, prevent ingress of foreign matters, vermin and rodents etc. The minimum number of louvers shall be provided

on the sides of enclosures and the louvers should be covered with SS or galvanized sheet fine (openings not more than 2.5 mm) mesh. The enclosure should have structural steel framework with lockable hinged door on HV and LV termination sides of the transformer. The gasketed doors shall facilitate the inspection of the transformer.

- b) The enclosure frame shall be fabricated using suitable CRCA pressed and shaped sheet steel of thickness not less than 3.0 mm for structural members and 2.0 mm for all doors/covers etc.
- c) All panel edges and door edges shall be reinforced against distortion/deformation by rolling, bending and addition of welded reinforcement members.
- d) The complete structure shall be rigid, self-supporting and shall be suitable for connecting ventilation hood on the top. To remove heat from the transformer, its metallic enclosure shall have sufficient heat dissipation capability in outdoor conditions, throughout the year without any additional cooling arrangement. GI or SS wire mesh shall be provided in the gap in between enclosure and ventilation hood to prevent entry of birds etc. Powder/enamel paint coated 3 mm thick perforated MS mesh shall be provided for enclosing the bottom side.
- e) The enclosure shall not have degree of ingress protection less than IP 33.
- f) Door switch with 2 NO. + 2 NC auxiliary contacts of required rating shall be provided. It will be used for providing interlock in the HV breaker circuit.

4.5 PAINTING

After thorough metal treatment enclosure surface shall be given two coats of enamel/powder paint. Double coat of corrosion resistant primer shall be applied before painting. The inside of the enclosure shall have semi—glossy paint finish. All metal parts not accessible for painting shall be made of corrosion resistant material. All paints shall be carefully selected to withstand heat and tropical weather conditions.

4.6 FITTINGS AND ACCESSORIES

- Following fittings and accessories shall be provided:
- HV/LV Terminals suitable for the purchaser's external conductors
- Rating, terminal marking and danger plates
- Three earth terminals per transformer, each suitable for earth conductor's of size 2 nos.
- 75x10 mm GI strip for earthing of the body of the transformers and its enclosures.
- Lifting lugs for :
- Complete transformer (with enclosure) Core-Coil assembly
- The under base shall be provided with channels etc.
- Four bi-directional rollers in base frame for movement of complete transformer assembly.
- The stopper arrangement to lock the transformer in the required position shall also be provided.
- Enclosure with provision for dismantling
- Marshalling box
- Neutral earth terminal with lugs.
- Six number PT100 RTDs with WTI display
- Off circuit tap links.

4.7 PERFORMANCE REQUIREMENT

- a) Transformers shall operate without abnormal heating at the rated KVA at any voltage within + 10 percent of the rated voltage of that particular tap.
- b) Transformer shall be designed for 110% continuous over fluxing withstand capability.
- c) The continuous and short time over loading capacities shall be furnished in detail. Over loads shall be allowed within the condition defined in the applicable standard. Terminal taps or any other auxiliary equipment shall not limit such over loading.
- d) The neutral terminal of windings with star connection shall be designed for the highest over-current that can flow through this winding.
- e) The bidder shall ensure that the design and manufacturing of the transformer shall be such as to reduce noise and vibration level. The sound level of the transformer with its enclosure in position shall not exceed 66 dBA measured in accordance with NEMA TR-I or IEC 60076-10 Standard
- f) The apparent charge limit shall be 20 pC during partial discharge test as per IS 11171.
- g) The transformer HV winding shall be suitable for vacuum circuit breakers switching.
- h) All other performance requirement as per the relevant standards and codes shall be met with the conditions specified above.

4.8 ROUTINE TESTS

The tests shall be as below:

- Measurement of Resistance of windings
- Measurements of voltage ratio at all taps and checks of voltage vector relationship,
- Check test for polarity
- Measurement of impedance voltage (principal tap), short circuit impedance and load loss at rated current
- Measurement of No-Load loss and current
- Separate source voltage withstand test
- Induced over voltage withstand test
- Measurement of insulation resistance
- HV tests on auxiliary & control wiring
- Calculation of the regulation and efficiency at rated load on unity P.F. and 0.8 P.F. lag.

All routine tests shall be carried out as per the IS 11171/2026. Type test reports shall be submitted for same type of transformer.

5 415 V SWITCHGEAR

5.1 CODES & STANDARDS

The design, construction, manufacture and performance of equipment shall conform to latest applicable BIS standards or equivalent standards and comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.

The relevant Indian Standards are :

Title	Code No.
Switchgear General Requirements	IS13947/BS5486/IEC60439-0, -1 & -2
Factory Built Assemblies of SWGR and Control gear for Voltages upto and including 1000V AC & 1200V DC	IS8623/BS5486/IEC60439
Air Break Switches	IS13947-P3/BSEN60947/IEC60947-3
Miniature Circuit Breakers	IS8828/BSEN60898
Low voltage Fuses	IS13703/BS1362/IEC269-1
Contractors	IS13947/BSEN60947-4/IEC60947-1
Starters	IS13947/BSEN60947-4/IEC292-1 to 4
Control Switches / Push Buttons	IS6875/BSEN60947/ IEC60044
Current Transformers	IS2705/BS7626
Voltage Transformers	IS3156/BS7625/IEC60186
Indicating instruments	IS1248/BS89/IEC60051
Making and Identification of Conductors and Apparatus Terminals	IS11353/BS159
A.C. Electricity Meters	IS722, 8530/BS5685 / IEC 145, 211
Degree of Protection	IS13947/IEC947-P1/ IP-52
Selection installation and maintenance of switchgear and control gear	IS10118
Bus Bar	IS613
Relays	IS3231/IS3842/BSEN60947-5-1 /IEC60255
Push Buttons	IS6875/BSEN60947/BSEN60037/IEC60037

5.2 FEATURES OF CONSTRUCTION

The switchgear shall be metal enclosed, modular type suitable for indoor floor mounting and shall have following features.

- Height shall not exceed 2300 mm
- Shall be Single front execution and fixed type
- Shall have designation labels both on front and rear sides

- All cable entries shall be from bottom
- Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.

The switchgear shall be divided into distinct vertical sections each comprising:

- A completely metal enclosed bus bar compartment running horizontally.
- Individual feeder modules arranged in multi-tier formation. It is essential that the modules are integral multiples of the basic unit size to provide for flexibility in changes, if any, at site.
- Enclosed vertical busbars serving all modules in the vertical section. For safety isolation of the vertical bus bars, insulating barrier with cut-outs shall be provided to allow the power stab contacts to engage with vertical bus bars.
- A vertical cable alley covering the entire height. The cable alley shall be minimum 300 mm wide for motor control modules and 500 mm wide for circuit breaker controlled modules.
- A horizontal separate enclosure for all auxiliary power & control buses, as required, shall be located so as to enable easy identification, maintenance and segregation from the main power buses. Tap – off connections from these buses shall be arranged separately for each vertical section.

The Switchgear shall be easily extendable on both sides by the addition of vertical sections after removing the end covers.

Operating devices shall be incorporated only in the front of switchgear.

Each shipping section shall have metal sheets at both ends.

Cable alley shall be provided with suitable hinged doors.

Rear of single front switchgear shall be provided with removable panels with captive screws.

All doors shall be with concealed type hinges and captive screws

Each vertical section shall be equipped with a space heater controlled by thermostat

Each switchgear cubicle shall be provided with interior lighting with a 20 W fluorescent tube with on/off switch.

A 240 V, 1 phase, AC plug point shall be provided in the interior of each cubicle with on-off switch for connection of head lamps.

5.3 INTERCHANGEABILITY

All identical equipment and corresponding parts be fully interchangeable without any modifications.

Main and Auxiliary Buses

5.4 MAIN BUSES & TAPS

- a. Switchgear shall be provided with three phase or three phase and neutral bus bars.
- b. Bus bars shall be of uniform cross section throughout the length of the switchgear, and up to the incoming terminals of feeder circuit breaker / switch.
- c. The bus bars shall be made of high conductivity aluminium alloy of E91E grade as specified in the SLD
- d. Bus bars shall be provided with at least the minimum clearances in air as per applicable standards for a 500 V, 3 phase system.
- e. All bus-bars, bus-taps shall be insulated with close fittings sleeve of hard, smooth, dust and dirt free plastic insulation of high dielectric strength (450 V/mil) to provide a permanent high dielectric non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing and in fast colours to indicate phases. The joints shall be insulated in such a way as to provide for accessibility of contact bolts for maintenance. The dielectric strength and properties shall hold good for the temperature range of 0 deg. C to 90 deg. C. If the insulating sleeve is not coloured bus-bars shall be colour – coded with coloured bands at suitable intervals.
- f. Busbars shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents for the associated switchgear. Busbar supports shall be made of glass reinforced moulded plastic material or DMC/SMC.
- g. Separate supports shall be provide for each phase of the busbars. If a common support is provided for all three phases, anti-tracking barriers shall be incorporated.
- h. Busbar joints shall be complete with high tensile steel bolts and Belleville washers and nuts. Busbars shall be thoroughly cleaned at the joint locations and a suitable contact grease shall be applied just before making a joint.

5.5 AUXILIARY BUSES

Auxiliary buses for control power supply, space heater power supply or any other specified service shall be provided. These buses shall be insulated, adequately supported and sized to suit specified requirements. The material of control power

supply buses shall be electrolytic copper. The material for space heater power supply buses shall be same as that for the main power buses.

5.6 SHEET METAL WORK

The switchgear frame shall be fabricated using suitable mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2.5 mm.

- a. Frames shall be enclosed by sheet steel of thickness not less than 2 mm cold rolled or 2.5 mm hot rolled, smoothly finished, leveled, and free from flaws. Doors and covers shall be made of sheet steel of thickness not less than 1.6 mm cold rolled or 2 mm hot rolled. Stiffeners shall be provided wherever necessary.
- b. All panel edges and door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members.
- c. Cut-outs shall be true in shape and avoid of sharp edges.
- d. The complete structure shall be rigid, self-supporting, free from vibration, twists and bends.

5.7 PAINTING

- a. All sheet steel work shall be phosphated in accordance with the following procedure and in accordance with applicable standards.
- b. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.
- c. Rust and scale shall be removed by pickling with dilute acid followed by washing and running water, rinsing with slightly alkaline hot water and drying.
- d. After phosphating, thorough, rinsing shall be carried out with clean water, followed by final rinsing with dilute dichromate solution and oven drying.
- e. The phosphate coating shall be sealed by the application of two coats of primer suitable for finishing by powder coating.
- f. After application of the primer, the fabricated sheet steel work shall be subject to epoxy based powder coating. Shade of powder coating is subject to approval by the engineer.
- g. Each coat of primer and finishing paint shall be of a slightly different shade to enable inspection of the painting.
- h. The final finished thickness of paint film on steel shall not be less than 100 microns, and shall not be more than 150 microns.
- i. Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces.

5.8 MOTOR PROTECTION CIRCUIT BREAKERS (MPCBs)

MPCBs shall be 3 phase devices suitable for direct connection to system having fault level of 50kA r.m.s. MPCBs shall be complete with inbuilt bi-metal overload protection, short circuit protection and protection against single phasing.

Bi-metal overload protection shall have range suitable for motor F.L.C.

The protections shall provide at least 1 0 potential free output alarm contact for use in control circuitry, alarm and signal to SCADA system.

5.9 MOTOR STARTERS

Switchgear design shall be ‘fuseless’ type i.e. fuses shall not be used for protection of the circuits. MPCBs, MCCBs, MCBs and ACBs shall be used as appropriate.

The selection of starters shall be made according to the rating of the motor used with the equipment. The selection shall be done as follows:

- Upto 10 HP : Direct On line Starter
- Above 11 HP to 50 HP : Star-Delta Starter
- Above 50 HP : Soft Starters

All starter feeders shall have individual ammeter with selector switch.

At least 15% spare starter modules of each type and kW rating subject to a minimum of 1No. shall be provided on each bus section of the MCC.

All the motor starters shall be wired to communicate with PLC and SCADA system, as well as local control station. Each motor starter shall have following minimum facilities-

Digital Input (DI) : “Run” and “Stop” from PLC for maintained command, “Run” and “Stop” can be common. For momentary commands, these shall be separate.

Digital Output (DO) : “Running” & “Tripping” feedback to PLC

5.9.1 Direct on-line starters (DOL)

Direct on-line starters shall be suitable for Class AC 3 utilization category suitable for type – 2 coordination as specified in applicable standards. Each DOL starter feeder shall be complete with Motor Protection Circuit Breaker (MPCB) with built in overload relay and single phasing preventor, contactor, ON-OFF-TRIP indication lamps, Start-Stop-Reset push button.

5.9.2 Star-Delta Starters

- a. Automatic star-Delta starters shall comprise three sets of contactors one for the line, one for the star point and one for the delta, and a timer relay to automatically change the connections from star to delta.
- b. Star-delta contactors shall be electrically interlocked to permit starting of the motor in the proper sequence, namely star contactor closing, line contactor closing, timer energized, timer contact de-energising the star contactor, and delta contactor closing.

- c. Start delta starters shall be suitable for Class AC 3 utilisation category suitable for type-2 coordination as specified in applicable standards.
- d. Each starter feeder shall be complete with MPCB/MCCB as appropriate with built in overload relay and single phasing preventor, 3 nos. contactors, ON-OFF-TRIP indication lamps, Start-Stop-Reset push button.

5.10 THERMAL OVERLOAD RELAYS

- a. Starters shall be complete with a three element, positive acting, ambient temperature compensated, time lagged thermal overload relay with adjustable settings. The setting range shall be properly selected in accordance with rating of the motor.
- b. Thermal overload relays shall be hand reset type.
- c. 'Stop' push button of the starter and hand reset device shall be separate from each other.
- d. Overload relay hand reset push button shall be brought out on the front of the compartment door.
- e. Overload relay shall be provided with at least one 'NO' and one 'NC' or one change-over contact.

5.11 SINGLE PHASING PREVENTORS

The relay shall be suitable for application to protect reversible and non-reversible motors. The relay operation shall be independent of the motor KW rating, the loading conditions prior to the occurrence of the single phasing and rpm of the motor. The relay shall be of the fail-safe type and shall operate to trip the motor when the relay internal wiring is accidentally open circuited. The single phasing preventor should be current sensing type.

5.12 MOULDED CASE CIRCUIT BREAKERS

- a. Moulded case circuit breakers (MCCBs) shall be provided for use in lieu of switch fuse for the motor controls. The MCCBs shall conform to BSEN60947-2 and the latest application standards.
- b. MCCBs in AC circuits shall be of triple pole construction arranged for simultaneous three pole manual closing and opening and for automatic instantaneous tripping on short circuit. Operating mechanism shall be quick-make, quick-break and trip-free type. The ON, OFF and TRIP positions of the MCCB shall be clearly indicated and visible to the operator when mounted as in service. Front of board operating handle shall be provided.
- c. MCCBs shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relays settings of the motor starting equipment and the mechanical stress caused by the peak short-circuit current of value associated with the switchgear rating. The maximum tripping time under short circuit shall not exceed 20 milliseconds.

- d. MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.

5.13 CURRENT TRANSFORMERS

- a. Current transformers shall be of the dry type resin cast.
- b. Current transformer shall have a short time withstand rating equal to the short time withstand rating of the associated switchgear for one second.
- c. Unless otherwise specified, the minimum performance requirement of current transformers are as follows :
 - Measuring CTs – 10 VA, accuracy class 1.0 and an instrument safety factor of less than 5.
 - Protective CTs – 15 VA, accuracy class 5P and accuracy limit factor of 10.
- d. Test links shall be provided in both secondary leads of the Cts to easily carry out current measurement tests.
- e. All current transformers shall be earthed through a separate earth link on the terminal block to permit easy measurement of the current transformer insulation resistance.

5.14 VOLTAGE TRANSFORMERS

- a. Voltage transformers shall be of dry type cast resin.
- b. Unless otherwise specified, the minimum performance requirements of voltage transformers are as follows :
 - Measuring VTs – 50 VA per phase and accuracy class 1.0.
 - Protective VTs – 50 VA per phase and accuracy class 3.0
- c. All secondary windings of voltage transformers including open delta windings shall be rated for 110 V per phase.
- d. Voltage transformers shall have a continuous over – voltage factor of 1.2 and short time over-voltage factor as follows:
 - 1.5 for 30 seconds in case of effectively earthed system.
 - 1.9 for 8 hours in case of non-effectively earthed system.
- e. Voltage transformers shall be complete with suitable rated primary, secondary and tertiary fuses. Primary fuses shall have a rupturing capacity equal to the rupturing capacity rating of the associated switchgear. HRC Fuses shall be provided on each sub circuit.
- f. It shall be possible to replace voltage transformers without having to de-energise the main bus bars.

- g. The terminals of V.T. secondary and tertiary windings which are required to be connected to earth shall be earthed by an isolating link without a fuse.

5.15 RELAYS

The following clauses shall apply to the protective relays.

- 1 Relays shall be –

- Numerical type with communication facility.
- Enclosed in dust proof flush mounting draw out type cases.
- Accessible for setting and resetting from the front.
- Provided with positive acting hand-reset flat indicators visible from the front.

Access to setting devices shall be possible only after the front covers are removed.
Access to resetting devices shall be external to the case.

- 2 Auxiliary relays shall be rated to operate satisfactorily between 70% and 110% rated voltage.
3. Each relay shall be provided with at least two separate voltage free contacts.

5.16 INDICATING INSTRUMENTS AND METERS

1. Electrical indicating instruments shall be of minimum 96 mm square size, suitable for flush mounting. All instruments shall be generally of the same pattern and appearance throughout which perform similar duties shall be of uniform type and manufacture.
2. Indicating instruments shall be digital type preferably and shall have class 1.0 accuracy.
3. Watt hour meters shall be electronic type

5.17 INDICATING LAMPS

- 1 Indicating lamps shall be :

- Cluster LED Type
- Provided with series resistors as required
- Provided with translucent lamp covers of colours ‘Red’. ‘Green’ and ‘Amber’ as required in the control wiring diagrams. Cover shall comply with BSEN 60037.
- Bulbs and lenses shall be easily replaceable from the front.

5.18 CONTROL AND SELECTOR SWITCHES

- 1 Control and selector switches shall be :
 - Of the rotary type.
 - Adequately rated for the purpose intended (minimum acceptable rating is 10 A continuous at 240 V AC and 1 A (inductive break) 220 V DC).
 - Provided with escutcheon plates clearly marked to show the positions.
- 2 Control switches shall be :
 - Of the spring return to normal type
 - Provided with pistol grip type handles.
- 3 Selector switches shall be :
 - Of the maintained contact stay put type. Switches in ammeter circuits shall have make-before-break type contact.
 - Provided with oval handle.

5.19 PUSH BUTTONS

- 1 Push buttons shall be :
 - Of the momentary contact, push to actuate type rated to carry 10 A at 240 V AC and 1A (inductive breaking) at 220 V DC.
 - Fitted with self reset, 2 NO and 2 NC contacts.
 - Provided with integral escutcheon plates marked with its function.
- 2 'Start', 'Open', 'Close' push buttons shall be green in colour.
- 3 'Stop' push buttons shall be red in colour.
- 4 All other push buttons shall be black in colour.
- 5 'Emergency Stop' push buttons shall be of the lockable in the pushed position type and rotate to release and shall be shrouded to prevent accidental operation.

5.20 CONTROL TRANSFORMER

Each Bus section in the MCC shall be provided with a control transformer 415/110V, single phase, dry type and of adequate VA rating to cater to loads of control circuitry of the feeders connected to that bus. The transformers shall be adequately protected on the primary side by an MCCB and on the secondary side by an MCB.

The secondary of the control transformer shall be taken to a control bus to be run throughout the length of the MCC.

5.21 WINDOW TYPE ALARM ANNUNCIATORS

- 1 The alarm annunciation scheme wherever specified in control wiring drawings shall incorporate the following features:
 - Visual indication of the fault by means of steadily lit alarm windows.
 - Audible alarm on the occurrence of the fault.
 - Red facia units to differentiate trip alarm from non-trip alarms.
 - Acknowledgement of occurrence of fault, incorporating audible alarm cancellation features.
 - Resetting the scheme after the faults have been cleared.
 - Facility to test the healthy condition of the lamps automatically excluding units indicating existing faults.
 - Prevention of mal-operation of the scheme when the push buttons are pressed incorrectly or in a wrong sequence.
 - Initiation of the complete sequence of audiovisual alarms in the event of a new fault occurring at the time of accepting an existing fault.
 - Suitable for operation on a 2 wire, AC supply with a supply voltage variation between 80% and 110% of the rated voltage.
 - Suitable for operation for fleeting (15 milli sec. duration) as well as the persistent faults.
 - Facility for a separate audio-visual alarm to indicate 'Alarm supply failure'.
 - facility for duplicating the audio-visual alarm at a second location.
- 2 Window alarm annunciators shall incorporate the following constructional features:
 - Flush mounted facia units, each of which is provided with two lamps and a series resistor and a ground glass plate in front of the inscription.
 - Plug in relays mounted behind the facia units.
- 3 The alarm annunciation scheme shall comprise the following equipments.
 - A facia unit complete with relays for each fault.
 - A common alarm bell
 - 'Accept', 'Reset' and 'Lamp Test' push buttons.
 - Alarm supply failure, 'Accept' and 'Reset' push buttons.

5.22 TESTS

The following tests shall be conducted at Manufacturer's works

All routine tests shall be conducted in presence of the Purchaser / Consultant, as follows.

- a) Visual Inspection, GA check, Dimension check, Bill of Material check.
- b) Functional Test
- c) High Voltage Test
- d) Insulation Resistance Test (Before and After HV)

6 GENERATOR PROTECTION, CONTROL, METERING AND AUTO-SYNCHRONISATION PANEL

The scope of work shall include supply of automatic and manual synchronisation panel for all the 4 sets. Proprietary GCU (Generator Control Unit) shall be provided for complete control and operation of DG set.

Auto-exercising shall be with field audio pre-warning with 3 minutes delay for safety of operating and maintenance staff. Start and Stop control will be from the PLC, which will be governed by number of pumps that are required to run.

The control panel shall also provide facility for load sharing in terms of active and reactive power. Multi-function meter to be provided on the switchgear shall communicate with SCADA system to transfer data on electrical parameters of each DG set.

GCU specification:

- Isolated & mains parallel operation
- Import / export control at interchange point
- Softload features
- Open / closed transition
- Synchronisation with phase matching and slip frequency
- Synchro check switcher
- AMF
- load sharing in terms of kW and kVA
- Load – dependent start / stop for up to 32 units
- True r.m.s current sensing
- kWh, kvarh meter
- Counters for engine starts, operating hours, maintenance call

Protections:

Generator:

- Over - under voltage
- Over – under frequency
- Unbalanced voltage
- Dead bus detection
- Overload
- Unbalanced load
- Reverse – reduced power
- Over fluxing
- Definite over current and time – over current
- Inverse time over current
- Measured ground fault
- Power Factor
- Phase rotation
- Restricted Earth Fault &
- Standby Earth Fault

Engine:

- Over – under speed
- Battery under – over voltage
- Auxiliary excitation
- Speed / frequency mismatch

Mains:

- Load
- kVAr
- Over – under voltage
- Over – under frequency
- Phase shift
- Rotation field

Note: Panel construction features and other switchgear specification as per Chapter 5 - 415 V Switchgear, Volume 2, Section 2D, Electrical Specifications of this tender.

7 LOCAL PUSH BUTTON STATIONS

7.1 STANDARDS

- a. The design, manufacture and performance of the equipment to be supplied under the scope of this specification shall comply with latest revisions of relevant Indian Standards and rules or equivalent standards (ref.cl. 2, Sec. II B, Vol. II)
- b. The design and workmanship shall be in accordance with best engineering practices as applicable to industrial electrical equipment enclosures.

7.2 CONSTRUCTION

- a. Industrial Local Control Station enclosure shall be of Cast Aluminium LM6 alloy enclosure having minimum 3 mm thickness.
- b. The enclosure shall be weatherproof, IP-55 suitable for outdoor installation. Local control stations for use in hazardous areas shall be with Ex-d protection and shall be suitable for zone 1 application. These shall be CMRS certified. All mating surfaces of industrial LCS shall be with continuous non-deteriorating type special rubber gaskets/neoprene gaskets. An additional 2mm thick Aluminium canopy shall be provided to give adequate protection against weather.
- c. For ease in cable terminations, the minimum distance between the terminal blocks and the cable entry gland plate shall be 50 mm for 1.5 sq.mm. size cable.

7.3 CABLE ENTRIES

Two threaded entries shall be of 20 mm shall be provided on each Local Control Stations at the bottom for fixing the cable glands. Metallic / rubber plug shall be provided for sealing one of the cable entries.

7.4 EARTHING

The enclosure shall be provided with two (2) nos. of external earthing terminals and one (1) no. Internal earthing terminal each of 2.5 mm diameter complete with nut, spring washers for termination of 14 SWG G.I. wire.

7.5 WIRING

All internal wiring up to the terminal block in the Local Control Station shall be carried out with 1.5 sq.mm. stranded copper conductors. Wires shall be PVC insulated type of 650/1100V grade. The wire shall be terminated with crimping type lugs only and shall be provided with ferrules at both the ends.

7.6 PAINTING

The Local Control Stations shall be treated with two coats of epoxy primer after thorough cleaning and treating of the surfaces and shall be finally provided with two coats of epoxy based powder coating. Shade of final paint shall be 631 to IS 5.

7.7 NAME PLATE

Each LCS shall be provided with nameplate. Nameplates shall be made from rear engraved perspex with letters of size minimum 6 mm on black background. All nameplates shall be identical in size and shall be fixed with screws on the cover.

7.8 COMPONENT SPECIFICATIONS

7.8.1 Push Button

- a. Each push button shall be provided with 1 NO + 1 NC contacts, each rated to carry, make and break 10A at 240V AC.
- b. Colour of the actuators of "STOP" push button shall be RED and that of "START" push button shall be "GREEN". Stop Push Button actuator shall be mushroom head type and shall have stay-put feature i.e. once the "STOP" push button is pressed, it remains in pressed position until its actuator is turned in either direction. "START" push button shall be totally shrouded type to prevent accidental start of the motor.

7.8.2 Terminal Blocks

Voltage grade of terminal block shall be 660V. Current rating, their size and make shall be as per the requirement specified. Two nos. spare terminals shall be provided in each local control station.

7.9 DRAWINGS DATA & MANUALS

The various drawings and documents to be submitted along with the bid and after placement of order shall be as per the attached schedule. Before starting manufacture of the equipment, the CONTRACTOR shall take the approval of design drawings from the Engineer in writing.

7.10 INSPECTION & TESTING

The LCS shall be routine tested at manufacturer's works in the presence of Purchaser / his representative before dispatch to site.

7.11 SPECIFIC TECHNICAL PARTICULARS

S.N.	Description	Details
1	Material of Enclosure	Die Cast Aluminium alloy LM6
2	PUSH BUTTONS	Telemecanique/L&T/Siemens/Teknic
2.1	Actuator	"GREEN" for "START", "RED" for "STOP"
2.2	Type	Spring return for "START", mushroom head stay put for "STOP"
2.3	Standard to which equipment confirm	IS 8623 & IS 4237
3	TERMINAL BLOCK	
3.1	Type	Clip-on
3.2	Size	2.5 sq.mm.
3.3	Voltage grade	660V
3.4	Current rating	10A
4.0	INTERNAL WIRING	
	SIZE	1.5 sq.mm. Stranded copper conductor

8 POWER CAPACITORS & CAPACITOR CONTROL PANEL

8.1 CODES AND STANDARDS

Title	Code No.
Shunt capacitors for power systems	IS : 13925/BS1650
Internal fuses and internal overpressure disconnectors for shunt capacitors	IS : 12672
Metal enclosed switchgear	IS : 3427 / BSEN 60298 / IEC : 61439
Code of practice for phosphating iron and steel	IS : 6005/ BS : 3189
Specification for copper rods and bars for electrical purpose	IS : 613
Code of practice for phosphating iron and steel	IS6005/BS3189
Specification for copper rods and bars for electrical purposes	IS613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS12021

8.2 DESIGN FEATURES

8.2.1 Constructional Features

- a. The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.
- b. The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.
- c. The capacitors bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series rack shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units.
- d. The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers shall be provided in the cubicle to ensure proper ventilation.
- e. Each capacitor case and the cubicle shall be earthed to a separate earth bus in the cubicle.
- f. Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 Volts within one minute in accordance with the provisions of IS : 2834.

8.3 INDIVIDUAL CAPACITOR UNIT

- a. Each unit shall be a self-contained, indoor/outdoor type unit, with a rating at 50 cycles of 10, 25, 50, 100 or 200 KVA as required to give approximate bank capacitors required. Other things being equal larger sized units shall be provided. Total kVar output of the entire APFC equipment connected to a bus shall be adequate to improve the system power factor up to 0.995 lag.
- b. Bushings may be either of glass or porcelain and shall be joined to the case by solder-welded or other method which ensures an adequate and permanent seal.
- c. Each unit shall be non-inflammable dielectric immersed self cooled and hermetically sealed.
- d. Each unit shall satisfactorily operate at 135% of rated kVA including factors of over voltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any over voltage up to a maximum of 10% above the rated voltage, excluding transients.
- e. A weather-proof and corrosion-proof name plate shall be provided on each capacitor unit. The nameplate shall contain the information setout in IS : 2834.

8.4 SERIES REACTORS

The capacitor banks shall be provided with 1% series reactors for inrush current suppression.

8.5 UNIT PROTECTION

Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. A blown fuse shall give visual indication so that it may be detected during periodic inspection. The fuse blowing time shall coordinate with the pressure built up within the unit to avoid explosion.

8.6 CONTROL REQUIREMENTS : CAPACITOR CONTROL PANEL

This shall generally conform to below mentioned specifications.

- a. The control equipment shall be mounted in a panel made of 14 gauge sheet steel. The panel shall be of indoor or outdoor type as specified.
- b. The panel shall consist of -
 - Moulded Case Circuit Breaker (MCCB)
 - Capacity duty type Contactor

- Relays responsive to current / voltage / KVAR / PF as specified for automatic switching. The APFC relay shall have adequate number of steps, minimum 4 nos. to control individual capacitor control switching steps (minimum 4 nos.) connected to a bus.
 - Sequencing devices, timer and auxiliary relays for automatic sequential switching of the capacitors in and out of circuit.
 - Auto manual selector switches
 - Push button for opening and closing the power circuit.
 - Red and green lamps for capacitors ON/OFF indication.
- c. Contractors shall submit along with the bid typical control schematic for automatic switching.
- d. Data Sheets of all relays shall be submitted along with the bid.

8.7 TEMPERATURE RISE

The temperature rise above the specified ambient of any part of the capacitor and associated equipment shall not exceed the maximum permissible temperature limit as specified in IS : 2834 or its latest amendment.

8.8 TESTS AND TEST REPORTS

- a. All tests shall be conducted in accordance with the latest edition of IS : 2834 in addition to the tests specified, if any, in Data Sheet A.
- b. Type test certificates for similar capacitor units shall be furnished with the bid.
- c. Tests on control panel as per specification shall be conducted.
- d. Routine test certificates for bought out components shall be submitted.

8.9 RATING PLATE

The following information shall be given on the rating plate of each capacitor unit.

- a) Reference to IS.
- b) Manufacturer's name and or trade mark
- c) Manufacturer's Identification Number
- d) Rated output in KVA
- e) Rated Voltage

- f) Rated Frequency in Hertz
- g) Upper Limit of temperature category
- h) No. of phases
- i) Connection Symbol
- j) Discharge Device
- k) Type of Dielectric
- l) Reference to Self Healing Design
- m) Total Weight
- n) Type of Impregnant

9 NEUTRAL GROUNDING RESISTERS

1 Applicable Standards

The design, manufacture and performance of the equipment shall comply with all currently applicable standards, regulations and safety codes in the locality where the equipment will be installed.

2. Design Requirements

- a) The resistors shall be non-inductive, in stainless steel construction.
- b) The grids shall be securely supported at sufficient number of points so that no damage is caused to the grids due to vibrations. The resistor elements shall be insulated from supporting bars by mica tubes.
- c) All the resistor elements comprising one stack shall be internally connected and end terminals shall be brought out of tank enclosure in the form of bushings. The line side shall be suitable for termination of 6.6 kV, Al/XLPE cable i.e. line side provided with a cable box. The earth side shall be a bare bushing suitable for termination of G.I. conductor, of 50 x 6 mm size.
- d) The enclosure for the resistors shall be CRCA sheet steel of thickness not less than 2.0 mm. Main frame shall be rigid and fabricated out of steel angles. The sheet steel shall undergo treatment as in HV & LV switchgear.
- e) The enclosure shall be provided with louvers for heat dissipation. The louvers, however, shall be provided with fine wire mesh to provide degree of protection not less than IP23
- f) Stand insulators shall be provided for supporting the enclosure and isolating it from ground.

3. Tests

The following tests shall be conducted at Manufacturer's works

All routine tests shall be conducted in presence of the Purchaser / Consultant, as follows.

- a) Visual Inspection, GA check, Dimension check, Bill of Material check.
- b) Resistance Measurement
- c) High Voltage Test
- d) Insulation Resistance Test (Before and After HV)

10 6.6 KV SOFT STARTERS

1. These being 6.6 kV grade equipment, the applicable standards, design, constructional features and testing shall be in accordance with the requirements stipulated for 6.6 kV metal clad switchgear.
2. FCMA (Flux Compensated magnetic amplifier) Technology shall be offered. Soft starters shall be of proven design and make. At least 25 nos. starters of similar voltage and kW rating shall be in successful operation for last 3 years as on date of award of work. The performance of these soft starters shall be certified by not less than General Manager or Ex. Engineer of that organization. If required MCGM shall have authority to visit & verify the performance of these soft starters.
3. The FCMA Tech. starters may be either line (6.6 kV) side or neutral side of the motor, depending upon the system design by the contractor.
4. The FCMA Tech. shall achieve smooth starting of the motor i.e. gradual acceleration, preventing jerks and extending the life of the driven equipment. The controls, interlocks and interface with the upstream VCB shall be PLC based. These are to be located in the substation building in Electrical panels room.
5. Starting current of the motor shall be preferably limited to 3.0 times the full load current of the motor.
6. Operationally the FCMA Tech. shall provide the following features:
 - a) Interlock with the main 6.6 kV CB of the motor so that the main C.B. can be switched 'ON' only when FCMA Tech. is in the circuit.
 - b) Supervise current taken by the motor and provide bypass to FCMA Tech. when appropriate i.e. when the motor has picked up. This may be time based supervision.
 - c) In case the motor fails to start, as sensed by the current monitoring system, the FCMA Tech. shall provide tripping signal to the main CB and annunciate the trouble.
 - d) Facility, by way of tappings on the FCMA Tech. shall be provided to fine tune the FCMA Tech. such that it shall be possible to optimise acceleration of the motor at site. This is required to ensure that the motor does not take abnormally long time to accelerate or too short time drawing very high acceleration current. It shall be the responsibility of FCMA Tech. starter supplier to design his FCMA Tech. compatible with the supplied motor. The application check i.e. acceleration current and acceleration time shall be subject to approval by the Engineer.
7. The FCMA Tech. shall be of oil less design. The whole starter assembly shall be maintenance free.
8. The FCMA Tech. shall not induce any eddy currents in nearby magnetic structures or create any electromagnetic interference. In case of any specific stipulation by the manufacturer of the FCMA Tech. starter, the same shall be clearly spelt out in the Bid.

9. Control/interlocking logic shall be executed through a dedicated PLC mounted on the soft starter panel.
10. The power linkwork shall be insulated with Full insulation heat shrinkable sleeving, as in case of 6.6 KV switchgear.
11. Tests

The following tests shall be conducted at Manufacturer's works,
All routine tests as per relevant IS and as recommended by the manufacturer of the equipment shall be conducted and the same shall be witnessed by the Purchaser / Consultant.

1. Visual Inspection
2. Dimensional checks
3. Electrical checks- Insulation resistance before & after HV, HV test, Control Logic test
4. Temperature rise test on bus bars & vacuum contactor
5. Load acceleration test

11 POWER & CONTROL CABLES

11.1 CODES AND STANDARDS

Title	Code No.
PVC insulated cables (for voltage up to 1100V)	IS:694
HRPVC & PVC insulated cables heavy duty	IS:1554
Cross linked polyethylene insulated PVC sheathed cables	IS:7098
Low frequency cables and wires with PVC insulation and sheath	IEC:189-1 & IEC-189-2
PVC insulation and sheath of electric cables	IS:5831
Polyethylene insulation and sheath for electric cables	IS:6474
Conductors for insulated electric Cables	IS:8130
Methods of test for cables	IS:10810
Specification for drums of electric cables	IS:10418
Specification for PVC insulated cables for electricity supply	BS:6346
Specification for PVC insulation and sheath of electric cables	BS:6746

11.2 DESIGN REQUIREMENTS OF CABLES

Cable shall be capable of operating satisfactory performance when laid on trays, trenches, ducts, and when laid directly buried in the ground.

Cables shall be capable of operating satisfactorily under a power supply system voltage variation of + 10%, frequency variation + 5% and a combined variation of + 10%.

The size of different cables to be used in various electrical equipment shall be considering following design criteria.

- i. Minimum size shall be 6 sq. mm, aluminium for power cable and 2.5 sq. mm. copper cable for small power rating equipment up to 2.2 kW motors. Control cable shall be 1.5 sq. mm copper
- ii. For Cable sizing, following factors shall be taken into consideration
 - a. Full load current
 - b. De-rating factor (Overall) under the conditions of laying as 0.6
 - c. Total voltage drop from LT of the transformer to MCC bus as 2% and from MCC to individual load (motor) as 3%.
 - d. For lighting circuits, the voltage drop at the farthest end shall not exceed 5%.
 - e. Short circuit current and its duration as applicable viz. effective let through energy the cable is required to withstand.

Cables shall normally be laid under following conditions:

i.	In air	:	Ambient temperature of 47°C
ii.	In ground	:	Ground temperature of 35°C
iii.	Depth of laying in ground	:	600 mm for LT Cables
iv.	Thermal Resistivity	:	120 Deg. Cent. Cm/Watt
v.	In trays	:	single layer touching each other

The cable shall withstand all mechanical and thermal stresses under steady state and transient operating conditions.

11.2.1 6.6 kV grade XLPE insulated FRLS Cables

A. APPLICABLE CODES AND STANDARDS

The following codes and standards (latest editions inclusive of all amendments) or equivalent standards are applicable.

Code No.	Title
IS:7098 (Part-II)	Cross linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 kV up to and including 33 kV
IS : 5831	PVC insulation and sheath of electric cables
IS : 6474	Polyethylene insulation and sheath for electric cables
IS : 8130	Conductors for insulated electric cables
IS : 3975	Mild Steel wires, strips and tapes for armouring of cables
IS : 10810	Methods of test for cables
IS : 3961 (Part II)	Recommended current ratings for cables PVC insulated and PVC sheathed heavy duty cables
IS : 1753	Aluminium Conductors for insulated cables
IS : 10418	Specification for drums of electric cables
IS : 2633	Methods of testing weight, thickness and uniformity of coating on hot dipped galvanized articles
IS : 209	Specifications for Zinc

B. DESIGN AND CONSTRUCTION

GENERAL

The design and construction of electrical power and control cables shall be in accordance with the codes and standards as specified.

All electrical power and control cables shall have coloured cores as follows.

Cable type	Power & Control Cables
Single core	red or black
Two cores	red and black
Three cores	red, yellow, blue
Four cores	red, yellow, blue, black
Five cores	red, yellow, blue, black, green white numerical printed on

The black sheath is for the neutral and the other colors are for the phase conductors.

For multicore cables (i.e. above 4 cores) for control applications, the core numbers shall be printed on each cable core for identification (i.e. nos. 1,2,3,4,5,6,7... upward).

All cables shall be suitable for operation under the following conditions:

- Directly buried in ground.
- Run in buried P.V.C., concrete or all steel ducts.
- Runs fastened to cable rack or tray in open air.

The cables shall be capable of continuous operation at highest system voltage as specified with maximum conductor operating temperature of 90°C and maximum temperature under fault conditions of not more than 250°C.

CONDUCTOR

The cable conductors shall be of stranded, high purity aluminium / annealed high conductivity copper conductors laid up and rendered smooth and free from defects likely to injure the insulation and conforming to IS 8130.

Smaller sizes shall be circular in formation and comprise several strands. Larger conductors to be stranded and shaped to produce a compact, less costly design. For cables having two or more than two cores, shall have all cores of uniform cross section.

INSULATION

The conductor screen, XLPE insulation and insulation screen shall be extruded in one operation by 'Triple Extrusion' to ensure perfect bonding between the layers. The core identification shall be with coloured strips of Red, Yellow and Blue or by printed numerals to identify the phase conductors.

The thickness of insulation shall be decided based on the permissible electrical stress (less than 3 KV/mm).

INSULATION SCREEN (over individual core)

The insulation screen shall consist of two parts

- Non metallic, semi-conducting compound extruded directly over insulation and fully bounded. A layer of semi conducting fabric tape shall be provided over the extruded layer to give bedding to the metallic part of screen.
- Metallic screen consisting of nonmagnetic metal in the form of a tape or wire.

INNER SHEATH

For all cables having two or more cores, inner sheath shall be applied over laid cores either by extrusion or by wrapping. The inner sheath shall be applied as circular as possible and to fit closely on the laid up cores so that it can be removed without damage to the insulation.

The inner sheath shall be of vulcanized rubber/proofed or plastic tap and shall not be harder than PVC used for insulation. This shall conform to requirement of types ST-2 of IS 5831. The thickness of sheath shall be not less than 0.7 mm.

BINDER TAPE

Binder tape shall be provided above metallic screen.

WATER PROOFING

By means of suitable non woven waterproofing tape under the metallic screen and plastic laminated tape or aluminium laminated tape above to the binder tape.

ARMOURING

Armouring shall be applied over inner sheath, where specified and shall be of galvanized steel strip as per IS 3975. The armour shall be applied as closely as possible with left hand direction of lay. For cables having diameter over the inner sheath less than 13 mm, the armour shall be of galvanized round steel wires or galvanized steel strips. The dimensions and resistance of armour shall be as per IS 1554 part I.

FRLS OUTER SHEATH

Extruded FRLS PVC over the metallic screen/armour shall be provided which shall conform to Type ST2 compound. To protect the cable against rodent and termite attack, suitable chemicals shall be added into the PVC compound of outer sheath.

In addition common covering for the three cores, fillers etc. shall be provided. The dimensions of insulation, armour and outer sheathing shall be governed by values given in Table 1, 3 & 4 of IS 7098, Part II.

C. SEALING AND DRUMMING

Both ends of every length of cable shall be sealed properly immediately after tests at manufacturer's premises.

The cables shall be rolled on suitable wooden or steel drums. The drum shall be marked with following.

- Make
- Cross sectional area of the cable with no. of cores.
- Voltage grade and type of cable.
- Length of cable, wt. of cable drum including cable.

- Direction of rotation of drum by arrow marking.
- ISI certification mark.

For all cut lengths of cables which are to be delivered to the client, approved sealing caps of correct size shall be supplied and properly mounted immediately after the respective cable length is cut.

D. INSPECTION AND TESTING

Performance and acceptance tests for electrical power and control cables shall be carried out at manufacturer's works which shall be witnessed by the Client/ Engineer- in charge deputed by the client shall be accepted. Copies of type test certificates, as per relevant standards, shall be furnished by the contractor along with the bid.

The required tests on the cables shall include but not limited to the following:

- High Voltage Test
- Conductor Resistance Test
- Armour Resistance Test
- Thickness of Insulation
- Test for Flame Retardance
- Insulation Resistance Test
- Tests applicable for FRLS cables

11.2.2 1100 V grade XLPE insulated FRLS Power cables

Cables shall be insulated with XLPE insulation. The inner sheath over laid up cores shall be XLPE and outer sheath over the armour shall be extruded FRLS PVC compound type ST-1. The voltage rating shall be 1100V and confirming to the latest IS. The cables shall be of aluminium conductor, stranded grade H4 class2 as per IS 8130.

11.2.3 1100 V grade XLPE insulated FRLS Control cables

Cables shall be insulated with XLPE. The inner sheath over laid up cores and outer sheath over the arm shall be extruded FRLS PVC compound type ST-1. The voltage rating shall be 1100 V and confirming to the latest IS:1554 Part-I. The cables shall be of annealed copper conductors with a minimum size of 1.5 sq. mm.

11.2.4 Inspection & Testing

The cables shall be tested in accordance with the IS 1554/7098. The tests shall include:

- Test for conductor
- Test for thickness of insulation
- Test for laying up
- Test for thickness of laying up
- Test for thickness of inner sheath
- Test for armouring
- Test for thickness of outer sheath.
- Tests applicable for FRLS cables

11.2.5 Test Equipments

Contractor shall ensure to use calibrated test equipment having valid calibration test certificate from standard laboratories traceable to National Standards.

11.2.6 Precommissioning tests at site

After successful installation of LV cables, the cables shall be tested at site performing following tests.

- a) LV cables – Insulation resistance test.

12 LIGHTING SYSTEM

12.1 CODES & STANDARDS

Electrical lighting fittings general and Safety requirements	IS:1913/BS:4533
Code of practice for industrial lighting	IS:6665
Calculation of co-efficient of utilization	IS:3646(Part-III)
Industrial lighting fittings with metal reflectors	IS:1777
Decorative lighting outfits	IS:5077
Dust proof electric lighting fittings	IS:4012
Dust tight electric lighting fittings	IS:4013
Flood lights	IS:10322/BS:4533
Luminaries for street lighting	IS:10322 Part 5
Water tight electric lighting fittings	IS:3553/BS:4533, 5225 (1)
Bayonet lamp holders	IS:1258/BS:EN61184 /IEC:60061
Edison screw lamp holders	IS:10276/BS:EN60238
Fittings	IEC:60082
Cast acrylic sheets for use in Luminaries	IS:7569
Screwless terminal and electrical connections for lighting fittings	IS:10322
Emergency lighting units	IS:9583
Ignition proof enclosures, dust-tight for electrical equipment	IS:11005
Luminaries (Part I to V)	IS:10322

12.2 INDOOR LIGHTING SYSTEM

Normal A.C. lighting.

All indoor and outdoor areas will be provided with A.C. lighting and the same will be available as long as A.C. supply is healthy.

Emergency. Lighting.

At important locations, emergency lighting fixtures will be provided which will come in service when A.C. supply fails. These shall be fed from an inverter with a back up battery suitable for 2 hours back time.

The wiring for lighting circuits shall be done by 2 nos 1.5 sq. mm. copper flexible (red & black colour) wires for phase & neutral and 1 no 1.0 sq. mm. green wire for earthing, run in heavy duty GI conduits for indoor areas. For outdoor lighting, wiring shall be done by armoured cables.

12.3 OUTDOOR LIGHTING SYSTEM

All outdoor areas will be provided with A.C. lighting and the same will be available as long as A.C. supply is healthy.

Street lighting shall be done with swaged steel tubular electric poles of adequate height, at every 20 meters to give the required illumination levels.

12.4 ILLUMINATION LEVELS

The illumination levels to calculate the number of lighting fixtures for various areas shall be considered as follows or as approved by the Engineer of the Contract:

Sr. No	Area	Illumination Level (Lux)
i)	DG/Pump house	250 lux
ii)	Battery room	150 lux
iii)	Machinery service area	150 lux
iv)	Offices / conference room	300 lux
v)	H.V. / L.V. switchgear rooms	250 lux
vi)	Plant control rooms	300 lux
vii)	Store	150 lux
viii)	Cable Cellar	100 lux
ix)	All other indoor areas	100 lux
x)	Outdoor platforms and walkways	50 lux
xi)	Building entrances	100 lux
xii)	Outdoor plant areas	20 lux
xiii)	Roads (Secondary)	10 lux
xiv)	Main Roads	20 lux

12.5 LIGHTING DESIGN & DISTRIBUTION

- a. Lighting distribution board shall be provided and it shall supply power to various local lighting panels.
- b. Lighting panels shall be provided in various areas and circuit wiring to the lighting fixtures shall be made from these lighting panels. Lighting panel shall comprise of 32A TPN MCB with ELCB for incomer and 16A/10A MCBs for each out going single phase circuits.
- c. Lighting fixtures and fans will be grouped on the circuit wherever required. However, separate circuits shall be used for receptacles wiring.
- d. For the purpose of calculating connected loads of various lighting circuits, a multiplying factor of 1.25 will be assumed to the rated lamp wattage for mercury vapour, sodium vapour and fluorescent lamp fixtures to take into account losses in the control gear. Also a loading of 100 watts and 500 watts shall be assumed for single phase 5 Amps and 15 Amps receptacles respectively.
- e. Lighting fixtures, receptacles, switches, conduits and junction boxes shall be properly earthed using 12 SWG G.I. wire.
- f. Receptacles of 5A and 15A, single phase, 3 pin shall be provided with switch. Receptacles in offices and control rooms shall be decorative type and in other areas shall be industrial type. Three phase receptacles shall be associated with TPN switch housed in the same enclosure. The receptacle shall become live only when the

associated switch in "ON" position. The enclosure for all outdoor receptacles shall be provided with degree of protection of IP-55.

- g. Generally maintenance factor of 0.7 shall be considered for lighting fixtures, in general plant area and 0.8 in offices and other air-conditioned areas.

12.6 LIGHTING FIXTURES

The fixtures shall be suitable for operation on a nominal supply of 240V, 1 ph, 50Hz AC with a voltage variation of +10% (i.e. 216 V to 264 V)

All lighting fixtures shall be with lamps and all necessary accessories for their satisfactory operation. Lighting fixtures shall be energy saver CFL based.

Each capacitor shall be suitable for operation at 240V + 10% 1ph 50 Hz with a suitable value of capacitance so as to correct the power factor of its corresponding lamp circuit to the extent of 0.98 lag.

Lighting fixtures shall be generally manufactured from sheet steel or aluminium of not less than 20 SWG.

Each fixture shall be complete with 1 four way terminal block for the connection and looping of incoming & outgoing supply cables. Each terminal shall be able to accept 2-2.5 sq.mm. copper stranded conductors.

Each lighting fixture shall be provided with a grounding terminal suitable for connecting 12 SWG G.I. wire.

The enamel finish shall have minimum thickness of 2 mils for outside surface and 1.5 mils for inside surfaces. The finish shall be non-porous and free from blemishes, blisters and fading.

Outdoor lighting fixtures shall be weatherproof, providing degree of protection not less than IP-55.

12.7 TYPE OF FIXTURES

12.7.1 Type- A : 1 x 20W Industrial LED Lighting Fittings:

The luminaire shall be weatherproof with glass cover, suitable for outdoor installation, degree of protection IP55 minimum, with mounting bent pipe & other accessories.

The luminaire shall consist of channel made from heavy gauge C.R.C.A. sheet steel. The fitting shall be provided with detachable stoved enameled reflector made from heavy gauge sheet steel. Accessories such as electronic ballast P.F. improvement capacitor, and lamp holders etc. are to be wired up to a terminal block with provision for earthing.

These are to be used for walkways, secondary roads and building periphery lighting.

12.7.2 Type-B : 2 x 20W Industrial LED Lighting Fittings :

The luminaire shall consist of channel made from heavy gauge C.R.C.A. sheet steel. The fitting shall be provided with detachable vitreous enameled reflector made from heavy gauge sheet steel. Accessories such as electronic ballast P.F. improvement capacitor and lamp holders etc. are to be wired up to a terminal block with provision for earthing.

These shall be used in LV/HV panel rooms and general industrial areas, stores, workshops, pump house.

12.7.3 Type-C : 2 x 20 W LED Mirror Optic Lighting Fixtures

General specifications shall be same as above. However, the fittings shall be provided with mirror finished louvers to provide high coefficient of utilization as well as to provide low glare. These shall be used in control room, electronic panel rooms, offices and laboratories.

12.7.4 Type-D : 2 x 20W corrosion proof LED Lighting Fixtures

The body and reflector shall made out of corrosion proof material like FRP. These fixtures shall be used in corrosive areas such as Lead Acid Battery rooms.

12.7.5 Type-E : 1 x 45W LED Well Glass Fixtures

These shall be suitable for outdoor application, minimum degree of protection IP55. These shall be used in outdoor plant areas such as outdoor platforms, walkways, DG shed etc.

12.7.6 Type-F : 100W, LED Flood Lights

Mounted on at least 12 m height poles, these luminaries shall be used for general illumination of areas such as fuel unloading and storage area.

12.7.7 Type-G : Energy Efficient LED Fittings

These shall be used at building entrance, toilets, emergency DG lighting where provided

12.7.8 Type-H : Emergency Lighting Fixtures

Emergency lighting fixtures shall be 20W LED tube light fixtures, AC operated & on AC supply. In normal case these fixtures shall remain OFF but in case of power failure the lamp will be switched ON automatically to inverter supply.

12.7.9 Ceiling / Exhaust Fans

Ceiling fans shall be 1200 mm sweep in size complete with electronic regulator and shall be provided in workshops, stores, department offices.

Domestic exhaust fans shall be installed in admin block & laboratory and heavy duty industrial exhaust fans in HV/LV panel rooms and transformer rooms. The fans shall be complete with mounting frame. The fan opening shall be covered by netted louvers to prevent the access of birds.

12.7.10 Flame proof Fittings

These fittings shall be suitable for installation in hazardous areas where diesel is stored in large quantity and shall be suitable for zone 2 application.

These shall be of following type:

1. 1 x 125W HPMV well glass fixtures suitable for outdoor areas

12.7.11 Outdoor Lighting

A. Street Light Pole

Outdoor lighting shall be done with swaged steel tubular electric poles as per IS and of adequate height to suit road width and an approximate spacing of 20m. The installation scope includes excavation required for pole, construction of 600 x 600mm concrete base for pole etc., earthing of pole, junction box & luminaire & laying of 3 x 2.5 YY cable from junction box to luminaire from inside of the pole.

The street light pole erection shall be complete with –

- 1 no: Street light pole of adequate height
- 1 no: 45W LED street lighting luminaire
- 2 nos: 50mm dia. G.I. conduit sleeves for incoming & outgoing cables up to J.B.
- 1.5 M long 20mm dia. Galvanised MS rod earth electrode for earthing of each 5th street lighting pole.

Loop-in-loop-out type, weatherproof Junction box with terminal blocks suitable for terminating 4 x 16 sq. mm. AYFY incoming cable & fuse. The Junction box shall be earthed from the same rod by 2.5 sq. mm. G.I. stranded wire.

The lighting cable shall be laid underground at a depth of minimum 750 mm below ground level with a protection of sand & bricks.

B. Street Light Luminaire:

The fitting shall be outdoor, weatherproof type and shall be integral type. It shall have a reflector of stove enamel type with heavy duty gauge deep drawn aluminium housing finished in white stoved enamel paint inside & grey hammertone outside fitted with a 3 pin/ E-27 porcelain lamp holder suitable for 45W LED lamp.

The protective cover shall be transparent clear acrylic cover, hinged, with a suitable neoprene gasket on the lamp reflector housing with toggles to make the luminaire dustproof, weatherproof and insect-proof.

The control gear housing shall be cast aluminium (LM6) alloy hinged with a sheet aluminium cover finished in stove enameled gray hammertone outside and zinc chromate inside.

Heavy duty polyester filled copper ballast, P.F. improvement condenser, lamp and mains connector block and an earthing terminal shall be assembled on a detachable tray suitable for 1 no 150W / 250W HPSV lamp.

"U" clamps are to be provided on to the control gear housing with 2 nuts for firm gripping to the supporting pole bracket of maximum angle at which fitting can be installed.

12.8 RECEPTACLE UNITS

Decorative and industrial type receptacle units of 5/15A, 15A, 30A SP/TP with switches/ MCBs shall be conforming to latest IS 3854 and sockets conforming to IS 1293. The units shall be suitable for mounting on stove enameled sheet steel boxes generally conforming to IS 5133 Part-I.

5/15A, 5 pin convenience switch socket outlets with indication lamp & fuse mounted on a PVC surface mounting box shall be installed in administration block. Wiring from lighting panel to each socket is covered in point wiring. One (1) receptacle outlet shall be provided at every 10m peripheral distance for indoor use. For outdoor use, one (1) receptacle outlet shall be provided at every 50 m distance.

15A single phase industrial sockets with 15A SP MCB & 2 earthing terminals shall be installed in rest of the area. 3 x 4 sq. mm AYWY cable shall be laid on wall from lighting panel to socket along with earth wire.

All the single phase socket outlets shall be 3 pin type viz. Phase, Neutral and Earth and all three phase socket outlets shall be 5 pin type, viz. 3 phases, neutral and earth. Plug tops shall be provided for 50% of the sockets provided.

12.9 DRAWING AND DATA

As part of the proposal, the bidder shall furnish relevant descriptive and illustrative literature on lighting fixtures, accessories and receptacles. That includes:

- Dimensional drawings
- Mounting details, cable entry and weight
- Assembly details
- Wiring connections
- Light absorption and utilization factors.

13 LIGHTNING PROTECTION SYSTEM

13.1 SCOPE:

The scope of work under these specifications cover supply installation, connection, testing and commissioning of lightning protection system at highest building consisting of the following.

1. Air termination network
2. Down conductors
3. Testing joints
4. Earthing

The lightning protection system shall comply with IS 2309- Protection of Buildings And Allied Structures Against Lightening- Code of Practice and Indian Electricity Rules.

13.2 SYSTEM

The lightning protection system shall be installed as indicated on above including.

An air terminal shall be installed on the highest structure and shall cover entire area of the pumping station. The air terminals shall be joined to horizontal roof conductor by means of rivet/clamps.

Down conductor shall be installed on the vertical surface of the structure. The down conductor shall be joined with roof conductors in the method as prescribed by the code. A test joint shall be provided in the down conductor 100 cm above the ground level at a place which is easily accessible for testing.

The down conductor shall be joined with earth termination network or to the earthing station.

The earthing station and earthing conductor shall be as per specification of Earthing.

Test joints in suitable enclosures shall be provided by the contractor for connection of down conductor and earth electrodes.

13.3 COMPONENT PART

Air Terminal and Roof Conductors

An air terminal shall consist of vertical conductor or a system of horizontal conductors and shall be installed along the outer perimeter of the roof.

No part of the roof shall be more than 9 m from the nearest horizontal protective conductor. All metallic projections, chimneys, ducts, vent pipe, railing, gutters etc on or above the main surface of the roof of the structure shall be bonded to and form part of the air termination network. The method and nature of fixing shall be simple, solid and permanent.

The air terminal shall be installed vertical on the highest point of the pump house and shall be clamped firmly with the structure. The roof conductor shall be laid horizontally on the roof surface.

Down Conductor

The number of down conductors shall be as follows:

A structure having a base area not exceeding 100 Sq.m. shall have only one down conductor.

For a structure having base area exceeding 100 Sq.m, the number of down conductors shall equal to smaller of the following.

One plus one for every 300 Sq.m. or part thereof in excess of the first 100 Sq.m. or one for every 30 m. of perimeter.

The down conductor shall be distributed round the outside wall of the structure. Any external metal running vertically through the structure shall be bonded to the down conductor at the top and bottom.

A down conductor shall follow the most direct path possible between the air terminal and the earth termination.

The size of the down conductor shall be similar to roof conductor/air termination network.

Each down conductor shall be provided with a testing joint in such a position that it is convenient for testing.

Joints and Bonds

The lightning protection system shall have as few joints as possible. Joints and bonds shall be mechanically and electrically effective e.g. clamped, screwed, bolted, riveted or welded with overlapping joint. The length of overlapping shall not be less than 25 mm for all types of conductor. Contact surface shall be first cleaned and then inhibited from oxidation with a suitable non-corrosive compound. Joints of dissimilar metals shall be protected from moisture by an inert, tenacious material.

Earth Resistance

The resistance from any part of the lightning protection system to earth shall not exceed 10 ohms before any bonding has been effected to metal in or on a structure or to services below ground. If the value obtained exceeds the specified one, then it shall be reduced by increasing number of earth electrodes.

14 D.C. POWER SYSTEM

The power supplies will operate from 415V ac and produce a 110V DC output voltage at full load current.

Voltage regulation- 0.02% for 10% mains voltage variation.
Load Regulation- 0.3% from zero to full load conditions.

The power supply shall incorporate an over voltage protection circuit, the components of which shall be independent of the voltage regulating circuit.

14.1 APPLICABLE STANDARDS

The battery charger and D.C. distribution board shall conform to the latest applicable BIS standards specified below or equivalent standards. In case of conflict between the standards and this Specification, this Specification shall govern.

Title	Code No.
Basic climatic and mechanical durability tests for components for electronic and electrical equipment	IS:9000
Environmental tests for electronic and electrical equipment	IS:9000
Metal clad base material for printed circuits for use in electronic and telecommunication equipment	IS:5921
Transformers and inductors (power, audio, pulse and switching) for electronic equipment	IS:6297
Printed wiring boards	IS:7405
Environmental requirements for semi-conductor devices and integrated circuits	IS 6553
Terminals for electronic equipment	IS:4007
Factory built assemblies of switchgear and control gear for voltages upto and including 1000 V AC and 1200 V DC	IS:8623/BS: 5486 /IEC:439
Air break switches	IS : 13947 (Part –3)BSEN60947-3
Miniature circuit breakers	IS : 8828/BSEN:60898
HRC cartridge fuses	IS : 9224/BS:88
Contactors	IS :13947(Part–3)/BS:775/ IEC:158-1
Control switches/push buttons	IS :6875
Indicating instruments	IS :1248/BC:89/ EC:51
Degree of Protection	IS :13947-(Part1)/IEC:947-1
Climate-proofing of electrical equipment	BSCP :1014

Title	Code No.
Code of practice for phosphating iron and steel	IS:6005/BS:3189
Semi-conductor converters	IEC:146
Semi-conductor rectifier equipment safety code	IS:6619
Specification for copper rods and bars for electrical purposes	IS : 613

14.2 ARRANGEMENTS

The DC Supply System shall comprise of the following items:

- Constant voltage, current-limiting rectifier
- One (1) battery bank of sealed maintenance free (SMC) Lead Acid batteries
- auxiliary equipment
- distribution section as integral part of the charger cubicle.

The output of the rectifier shall either rapid (boost) charge the battery along with the load or float charge the battery and simultaneously supply the power requirements of the load. In the event of failure of the AC mains supply to the rectifier, the battery shall, without interruption, immediately take over and supply the power requirements of the load.

14.3 RATINGS

All components shall be rated to withstand maximum occurring voltages, currents and loads.

- Construction and Electrical Requirements
- Accessibility and Enclosure

The unit shall have a complete metal enclosure of thickness at least 2 mm and shall be self-supporting, suitable for floor mounting. The protection class of the unit shall be at least IP42. The floor shall not be considered as being part of the enclosure.

- The maximum height shall not exceed 2.25 m.
- The maximum depth shall not exceed 0.8 m.
- The design shall include measures to avoid condensation as much as possible.
- Doors shall be equipped with locks. All components requiring maintenance shall be easily accessible from the front. Construction shall be free from burrs and sharp edges.

The following features for personal and electrical safety shall be incorporated:

- a. cubicles, sections, sub-sections and compartments which have to be accessible during operation, e.g. for fuse replacement shall contain no exposed live parts under normal operational conditions in opened situation (IP 20 in opened situation according to IEC 60529).
- b. maintenance of either charger shall be possible independently with the other charger supplying the loads.
- c. adequate means shall be provided to ensure the safe removal of fuses. Fuses can only be removed under no-load conditions. The fuses must be visible and easily removable when the compartment doors are open.

- d. adequate protection in the form of vertical and horizontal screening between the sections shall be provided to minimize the risk of accidental short circuits and to limit their propagation, if occurring.
- e. the insulation shall be capable of providing adequate and lasting protection under normal conditions and recognized over-current and voltage.
- f. the battery shall be installed in open steel racks in a designated A/C room with exhaust facility.
- g. the battery shall be positioned such that possible leakage of electrolyte or emission of gaseous products shall not cause any damage.

14.4 SECONDARY CABLES AND WIRING

Secondary wiring shall preferably have black-coloured PVC-insulation, shall have a cross-sectional area of at least 1.5 mm² and shall be of stranded copper. Wiring between terminals shall have no joints.

Wire shall not be mounted direct to metal, but shall be routed in insulated tubes, channels, cleats or plastic strips and kept in position by bundling the conductors with cable ties.

All wires shall be identified at both ends by means of ferrules of insulating material (slip on clips), marked in accordance with the related wiring diagram.

For all wires and conductors individual terminals shall be provided unless terminals are specially made for more than one conductor. Terminals shall be suitable for use of cable lugs.

Furthermore sufficient spare terminals shall be provided for future purposes with a minimum of 20% of the installed terminals.

14.5 MARKING

Unit to be provided with a name/rating plate made of corrosion resistant material fixed to a non-removable part. At least the following information shall be indelibly marked.

- year of manufacture.
- name of manufacturer.
- type and serial number of unit.
- nominal input current/voltage.
- nominal output current/voltage.
- IP classification according IEC 60529.
- Cell number.
- AH capacity.
- Type of Electrolyte.
- Phase or pole markings of AC and DC supply terminals.

All other name plates shall be 3 ply laminated phenolic (white-black-white) and engraved through to the black lamination. The edge of all nameplates shall be bevelled at 45 degrees. These name plates to be attached with self tapping screws.

Compartments and their component shall be provided with, but not limited to, the essential data as required (e.g. tag numbers, ratings, etc.).

Terminals shall be properly and clearly identified for easy identification by the operator. The capacity of the battery shall be given based on an equivalent 5 hour discharge time.

14.6 EXTERNAL CABLE TERMINATION

Cubicle shall be provided with a gland plate for bottom entry. Cubicle shall be provided with a plinth and provisions to support cables by means of metal (galvanized) clamps and brackets. Plinth height minimum 150 mm, maximum 200 mm. Terminals to be located close to the gland plate and earth rail.

14.7 BATTERY

Cells and Containers

The battery type shall be sealed maintenance free type. Inter-cells/Inter Tier, connection and terminals shall be insulated or otherwise provided with protective covering to prevent inadvertent short circuiting and these shall be adequately supported to withstand a battery through fault.

The terminals shall be capable of carrying the battery current as well as withstanding the effects of a short circuit that might occur at the battery.

The top tier of cells shall not be more than 1.5 meter above floor.

14.8 SWITCHING DEVICES

Switching (mechanical) shall be of the independent manually operated air-break type for continuous duty. They shall as a minimum comply with utilization category AC 23 for use on the AC side and DC-3 for use on the DC side of the rectifier in accordance with IEC publication 60947-3.

14.9 EARTHING

A copper main earth bar shall be fitted along the whole width of the cubicle. This bar shall be bonded to the enclosure of the unit. Within the cubicle an earthing bolt M10 shall be mounted. Metallic enclosure of all components shall be connected to the earth bus by independent PVC insulated copper conductor.

A high resistance shall be connected between Positive and Negative poles of the system and the centre point of the resistance shall be earthed through an earth fault relay, designed to indicate whether the earth fault exists on the Positive or Negative pole of the system. The Value of resistance connected across the Poles shall be such that in the event of a fault on either Pole the earth fault current does not exceed 10mA.

14.10 DC-EARTHING

The DC system is free from earth, therefore an earth fault detection system must be applied.

14.11 MATERIALS

A. Fuses

The fuses shall be of fast acting HRC type suitable for the thyristor duty in accordance with the relevant IS. Fuse holders for quick acting fuses shall be marked "special thyristor fuses".

B. Contactors

The utilisation category for DC contactors shall not be less than DC-3 and for AC contactors not less than AC-3.

C. Printed Circuit Boards

All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily and marked test pins. All PCBs shall have test points which shall be easily identifiable and accessible for testing.

D. Wiring

All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring will be 1.5 mm² and for power wiring shall be 2.5 mm².

E. Gland plate

Gland plate shall be of non magnetic material.

14.12 DISTRIBUTION SECTION

i. General

A separate section shall be provided in the battery charger section for a DC distribution system.

Even under extreme conditions of major short circuit or mal-operation there shall be no danger to persons in the vicinity of the assembly.

The electrical system voltage for the DC Distribution Section shall be as per the charger DC output voltage between -ve and +ve Bus.

ii. Ratings

The DC distribution section shall be rated on the basis of voltage and current ratings of the charger.

Current-carrying components shall furthermore be capable of carrying their rated current continuously at rated voltage and under specified service conditions without exceeding the permissible temperature limits.

iii. Performance Requirements

All components shall be capable of withstanding the dynamic, thermal and dielectric stresses resulting from prospective short-circuit currents without damage or injury of personnel.

iv. Internal Arrangement

The distribution section shall comprise a busbar system having one incoming feeder. The lay-out of the operational front and the location of the components of the assembly shall be arranged in a logical and systematic sequence and standardised throughout.

Proper alphanumeric notation, shall be used for identification and marking of polarities in conductors and terminals.

Interchangeable standardised components shall be used where feasible. It is preferred that spare compartments can be equipped to the maximum rating of the unit.

v. Positive and Negative Busbar Systems

Busbars shall be of high conductivity electrolytic tinned copper with joints by means of non-corrosive high tensile steel bolts, nuts and washers, and secured against loosening. Insulated busbars are to be provided

Compound or oil insulated busbar systems are not acceptable.

vi. Terminals

The board shall be provided with the facility of independent terminals to connect the main cable and the auxiliary cables. Types and sizes will be specified in the requisition and/or order.

Suitable terminating facilities of adequate dimensions and thermal rating shall be provided for each conductor.

At least 25% of spare terminal blocks of each size shall be provided for future use.

Within the panel compartment suitable clamping devices shall be provided for securing of the cables.

Two or more conductor terminations on one terminal are not acceptable unless the terminals are designed for more than one conductor. Shorting links should be used for such purpose.

vii. Miniature Circuit Breakers (MCBs)

The MCBs shall be single units of two pole construction and shall be provided for the incomer and outgoing feeders.

All live parts shall be totally enclosed in a heat resistant moulded insulating material housing.

Operating mechanism shall be quick make, quick break and trip free type.

The MCB's shall be provided with the following features:

- Instantaneous tripping on short circuit.
- Common trip bar for simultaneous tripping of both poles.
- Mechanical position indicator.
- Shrouded terminals.
- Auxiliary contacts for signalling.

The MCB's shall be suitably rated for D.C.

The 'ON', 'OFF' and 'TRIP' positions shall be clearly indicated and visible to the operator when mounted as on service. Front of board operating handle shall be provided.

viii. Wiring

Power circuit wiring shall be stranded, 500 V DC grade, colour black and red for -ve and +ve respectively.

Wiring to door mounted devices shall be via an easily detachable plug and socket connection and shall be suitable for hinge wire application.

Compartments shall be completely internally wired. Outgoing wiring shall be terminated at a terminal block. The terminal block shall be in the cable compartment.

ix. All terminal blocks shall be rated at 500 V DC for outgoing loads or 30 A (minimum).

All terminal blocks shall have a white plastic marking strip on the block. At least 25% extra terminal blocks shall be provided in the board for future use. Terminal blocks shall be provided for termination of cables in future to the spare feeders.

All wiring shall be identified by permanent slip-on plastic sleeves or ferrules at each terminal point in addition to the marking on the terminal blocks.

Boards shall be provided with drilled metal gland plates, which shall be grounded to the switchboard earth bus.

x. Earthing

Metal parts of equipment which to be earthed shall be connected by independent earth wire to an earth bar.

A bare copper, adequate horizontal earthing bar shall be provided at the bottom of the switchboard, along the entire length.

Joints in the earth bar shall be bare copper and bolted with galvanized or cadmiumized steel bolts, nuts and washers, secured against loosening.

For direct connection to the station earthing grid, earthing bolts M12) with nuts and spring washers shall be provided at both the ends of the main earth bar.

xi. Rating plates and nameplates

All components (switching devices, MCBs, instruments etc.) shall be fitted with a rating plate in accordance with relevant requirements. All functional units shall be clearly labelled to identify the service. All meters, switches etc. shall be labeled in accordance with the wiring diagrams.

Rating plates shall be made of corrosion-resistant metallic material and have indelible inscriptions.

Enamelled plates are not acceptable.

Each outgoing feeder shall be provided with nameplates, mounted on the front of a non-removable part.

Lettering shall be minimum of 5 mm in height. The edge of all nameplates shall be beveled at 45 degrees. The first and second lines shall describe the service with the item number centered on the third line. Nameplates shall be attached to their respective doors with nuts, bolts, and washers. Self tapping screws shall not be used. Nameplates shall correspond with the description and tag numbers as shown on the one line diagram.

The nameplates shall be of black non-deteriorating material and shall permit inscriptions with characters in white.

14.13 RECTIFIER

A. Battery "float"-charge operation

The rated output current of the rectifier shall be the current corresponding to the maximum load in KVA divided by the nominal DC system voltage, plus the current required to charge the battery from end cell voltage in 10 hours.

The rectifier steady-state DC output voltage variations shall be controlled to within plus 1% and minus 1% of the set value. This corresponds to the battery float-charge voltage during load variations between zero and the rated output current of the DC supply unit and during steady-state input voltage and frequency variations referred to in.

During transient input voltage depressions up to 20% of nominal voltage, the rectifier DC output voltage variations shall be controlled to a value that will at least prevent the initiation of battery discharge.

Facilities for on-line adjustment of the set value of float-charge voltage shall be provided. A suitable potentiometer shall provided on panel front for this purpose.

The DC output current of the rectifier, when operating under constant current limiting conditions, shall be controlled to within plus 2% and minus 2% of the set value.

The r.m.s. value of the voltage ripple, with the battery connected, shall not exceed 3% of the nominal DC system voltage.

B. Battery ““rapid”"-charge operation (Boost charging)

The "rapid"-charge cycle shall be according to a constant current/constant voltage characteristic.

The duration of the "rapid"-charge operation shall be automatic and after the elapsed time, will re-instate the rectifier output voltage to that corresponding to continuous float-charge operation.

When operating under constant current-limiting conditions, the DC output current of the rectifier shall be controlled to within plus 2% and minus 2% of the set value.

When operating under constant output voltage conditions, the voltage shall be controlled to within plus 1% and minus 1% of the set value.

The applied set value of the rapid-charge voltage and the duration for which it is applied to the battery shall restore the battery to 100% of its nominal ampere hour capacity within the specified 6-hour period.

Facilities shall be provided for on-line adjustment of the set of final voltage applied to the battery, by a potentiometer provided at the front of the panel.

C. Battery Discharge Operation

The battery voltage and capacity shall be such as to supply a direct current corresponding to the load specified in data sheet for while maintaining an output voltage within the permissible tolerances indicated in the data sheet.

The battery discharge requirements shall be fulfilled:

- under the prevailing climatic conditions including the minimum ambient temperature specified;
- by a battery which is in a partially charged condition.

D. DC Supply Unit Output Voltage

The voltage at the output terminals of the DC supply unit shall be limited to within plus 10% and minus 10% of the nominal DC system stated on the data sheet unless otherwise specified. The limitation applies during boost charge/continuous float-charge operations and during battery discharge operations and corresponds to the maximum load current for the specified discharge time.

Note: Voltage variations, due to transient phenomena are excluded from this requirement.

E. Audible Noise Limitation

If not otherwise specified, the sound pressure level measured at one meter distance from the equipment at any position, shall not exceed 70 dB(A) at any load between zero and rated output of the unit. If tonal components are present, the noise limit shall be taken 5 dB(A) more stringent i.e. 65 dB(A).

If the above values are unobtainable without the use of absorptive materials, precautions shall be taken to limit their effect on cooling, dust deposits and fire hazards, with minimal use of materials.

14.14 AUXILIARY EQUIPMENT

A. Indications and Alarms

The following indication equipment shall be provided on the cabinet door

- AC "mains supply failure"
- Rectifier "charge failure"
- Rectifier "high DC float voltage".
- Alarm contact to main alarm system.
- Rectifier "Low DC float voltage"
- Charger on boost
- Charger on Float
- Earth Fault

- Over temperature (shut down)
- Overload
- Reverse polarity (tripping)

Indications shall be provided with in-built test facilities. Alarm indications shall have manual reset facilities. They shall have a built-in memory to retain indication upon total supply failure.

B. Measurement

The following measuring instruments shall be provided:

- DC voltmeter measuring rectifier output voltage (with selection switch to measure position to Negative, Positive to earth and Negative to earth Voltage).
- DC ammeter, with zero at mid-scale, measuring battery current
- DC ammeter measuring rectifier output current.
- AC Voltmeter measuring input voltage.
- AC Ammeter measuring input current.
- Voltmeter for battery voltage.

The accuracy of all measuring instruments shall be not less than that according to class index 1.5 of IEC publication 60051.

C. Protection and Control

The following protective and control equipment shall be provided as a minimum requirement :

- rectifier AC mains contactor with on/off control circuit switch and fuses
- rectifier AC mains supply monitoring assembly
- manually operated float-charge/rapid-charge selector switch mechanically interlocked with the DC supply unit
- output isolation switch
- manually operated DC supply unit output isolation switch
- adjustable rapid-charge time control relay
- rectifier DC output circuit fuses
- battery circuit fuses.
- Auto/manual selector switch
- Float/boost
- Input side filter to reduce harmonics on the mains side
- Potentiometer to set float and boost voltages in 'Auto' mode (*)
- Potentiometer to vary float and boost voltage in 'Manual' mode (*)
- Range to be determined by VENDOR based on Battery requirements.

The AC mains supply monitor shall operate to open the rectifier AC mains supply contactor in the event of AC supply voltage depressions, or three-phase AC supply unbalance, that would otherwise impair the performance of the DC supply unit, and shall automatically re-close the contactor on restoration of AC supply voltage.

Rectifier output and battery circuit fuses shall be in accordance with IEC publication 60269-2. The rating of rectifier output and battery circuit fuses shall be coordinated such that the battery supply to the load is maintained in the event of rectifier bridge short circuits.

The rectifier shall have the necessary equipment to ensure soft/slow starting upon connection of the mains supply, to limit the in-rush current from the mains supply.

In addition the DC supply unit shall incorporate all the necessary control equipment to fulfil the performance requirements of this specification, and to protect the unit and its

components from excess current under all operating conditions. Selectively operating protective devices shall be incorporated as required to safeguard the unit and its components from the consequences of internal and external short circuits, over-voltages and any main or control circuit malfunctions, howsoever caused.

14.15 PERFORMANCE TESTS

A. Load-duration Test

All rectifiers to be supplied as part of the purchase order shall be subjected to a load-duration test performed at rated voltage for a period of not less than 48 hours prior to the execution of functional tests.

At least one rectifier of each group of identical rectifiers shall be loaded to rated (full load) current throughout the 48-hour test period. All other rectifiers to be supplied as part of the purchase order may be energized under partial load or zero load current conditions throughout the test period.

Vendor test reports shall state the dates and times on which the load-duration test was performed and shall record details of load current and any circuit or component malfunction identified during the test period.

B. Functional Tests

Functional tests shall be performed on all rectifiers. If during the execution of functional tests, an electronic component of the rectifier is required to be replaced, e.g. due to rectifier malfunction or failure of the unit to fulfil the performance requirements of this specification, then the rectifier load duration test (1.16.1) shall be repeated at rated current following which the functional tests shall be carried out.

15 INDUCTION MOTOR

A. Design requirement

The motor shall generally conform to IS325 or relevant equivalent internationally approved standards and shall be Energy Efficient (Eff – 1) type.

B. Performance and Characteristics

Motor should be capable of giving rated output under following supply conditions:

- | | |
|--|---------|
| i. Variation in supply voltage- | +/- 10% |
| ii. Variation in supply frequency- | +/- 5% |
| iii. Combined voltage and frequency variations | +/-10% |

Motor shall be suitable for full voltage DOL and / or Star- Delta starting.

15.1 SUBMERSIBLE TYPE INDUCTION MOTOR

- The submersible type motor shall conform to IS325 /IS9283 and submersible cable shall conform to IS9968. Use of equivalent standards of other countries or organisations may be permitted. (ref.cl. 2, Sec. II B, Vol. II)
- Motor should be capable of giving rated output under following supply conditions:
 - i. Variation in supply voltage- +/ - 10%
 - ii. Variation in supply frequency- +/ - 5%
 - iii. Combined voltage and frequency variations +/ -10%
- Motor shall be suitable for full voltage DOL and / or Star- Delta starting.
- The enclosure of the motor shall be IP-68.
- The guaranteed performance of the motor shall be met with tolerance specified in IS9283.
- Minimum three number thermistors in series are to be provided to sense the stator winding temperature.

16 INSTALLATION & COMMISSIONING OF ELECTRICAL EQUIPMENTS

16.1 GENERAL SPECIFICATIONS

These specifications shall be applicable to LT switchgear panels, motor control centers and other power and light distribution panels, instrument distribution and A.C. / D.C. control supply panels of various types and capacities. Manufacturer's instructions, drawings and instruction of the Engineer-in-charge should be studied and strictly followed during handling, erection, testing and commissioning of the switchgear. The switchgear should be handled with care by the experienced riggers under the guidance of a competent supervisor. Dragging of the panels should be avoided and use of a crane and trailer should be made for the handling purposes while transporting to various sites. The switchboards should be properly supported on the truck or trailer by means of ropes to avoid any chances of damage or tilting due to heavy vibrations. The switchboards should be lifted by making use of lifting eyes bolts only, fully tightened and after ensuring that panel supports, nuts and bolts are all in tact and tightened. All hardware (nuts, bolts, washers etc.) for electrical installation shall be stainless steel SS304 only. When lifting panels in packed conditions, utmost care should be taken to avoid any damage to any insulators, bushings, metering and protective equipment. The panels should be preferably kept inside the packing cases till foundations are ready.

Base channels should be grouted, leveled, in cement concrete pad for 415 V switchgear panels and other cubicle panels. Pedestal type panels and MCCs shall be erected by grouting base channels by bolts. A proper bonding surface should be made by chipping the floor while making cement concrete bearing pad for the switchboards. After cement concreting, all such foundations, grouted bolts shall be cured for a minimum period of 48 hours.

The switchboard panels should be taken from the packed cases and moved one by one to the proper place. All the panels should be assembled, aligned and leveled and it should be checked that panel to panel coupling bolts, bus bar links fit properly without any strain on any part. It should also be checked up that lowering, lifting, racking in and out operation of the breaker and all other motions are free from any obstruction. The fixing bolts should be grouted after satisfying all these equipment.

The panel shall be made dustproof and vermin proof with gaskets for inter panel joints and plugging all holes/cutouts. Tightening of bus bar/link connection and terminal connection should be carried out.

After completion of the panel erection, all the cubicles, switches, starters, C.T. and P.T. chambers, bus bar chamber, should be cleaned and checked for tightness of all the components. All the wiring connections should also be checked with drawing and tightened. Metering and protective C.T.s alarm, indication and protective relays should be fixed up if received loose. Polarity of P.T.s and C.T.s should be checked. All the moving parts should be checked for easy and free movement. Hinges of panel doors should be lightly lubricated to give free and noiseless movement.

Should the switchgear be wet or having a low IR value due to bad wiring, insulators, bushings or any other insulated parts, the entire switchgear should be dried up, and the IR value should improve to a safe level for commissioning the same. Care should be taken to protect the surrounding insulation from direct local heating during the drying up process.

Earthing shall be with proper size of the conductors as indicated in relevant drawing.

All the metering instruments, protective relays and other relays connections should be checked as per relevant drawing.

All the control wiring, P.T.s, bushings, bus bars, other alive parts of switchgear, incoming and outgoing cables should be meggered with 1000V. megger H.T. bus bars, circuit breakers, bushings on the switch gear should be pressure tested at recommended voltage as per Indian standard.

Electrical simulation tests should be carried out for all the protective, alarm and annunciation relays along with the manual operations of the circuit breaker.

Panels must be cleaned with vacuum cleaner.

Pre-commissioning Checklist.

Before commissioning any switch gear panel, circuit breaker, motor starters etc., the following points must be checked and ensured for safe energizing of the switch board:

- a. That the erection of equipment to be commissioned is complete in all respect with its auxiliaries and all other mountings including earthing.
- b. That all the openings in floor inside or outside the cubicle panels have been sealed off.
- c. That all the cubicles panel doors, gaskets are intact and no other opening exists for vermin entry.
- d. That all the metering instruments have been checked and calibrated.
- e. That all control circuit fuses are of proper rating and showing continuity.
- f. That all the indication lamps are healthy and in position.
- g. That the mechanical parts of breaker closing and tripping mechanism have been checked and lubricated and circuit breakers have been tested for contact travel, contact pressure and resistance and buffers are free and fully lubricated.
- h. That air vent pipe of C.B. is free and spouts/shutter mechanism is O.K.
- i. That auxiliary contacts have been checked for cleanliness and adequate contact pressure and auxiliary contacts in series with tripping circuit open with opening of breaker.
- j. That the polarity test and ratio test of all the P.T.s C.T.s is over.
- k. That the high voltage test of circuit breaker, bus bars and outgoing and incoming cables have been conducted and are satisfactory.
- l. That all the protective relays have been tested for primary and secondary injection tests. All thermal overload relays and the contractor coils and operation of all the current and voltage-operated relays have been tested.

- m. That the simulation tests for all protective, alarm and annunciation relays are O.K. and all the relays have been properly set.
- n. That the manual closing and tripping have been tried against shock and bouncing of the mechanism.
- o. That I.R. values have been recorded for bus bars, circuit breaker, incoming and outgoing cables, control wiring, and potential transformers. Joints resistance of high capacity bus bars have been recorded and found to be satisfactory.
- p. That fire fighting equipment like C.T.C., CO₂ or Soda Ash Extinguisher are kept ready for use.

16.2 CABLES TRAYS

Mounting – General Notes

Unless otherwise specially mentioned on the relevant layout drawings, all cable tray mounting works to be carried out as per notes given here.

Cable tray mounting arrangement type to be as marked on the layout drawing.

Assembly of cable tray mounting structure shall be fabricated, supplied, erected and painted by the electrical contractor.

Civil contractor will provide plate inserts in floor slabs at 1000 mm spacing for cable tray mounting structure.

Cable tray mounting structure to be welded to the plate inserts or to structural beams.

Wherever embedded plates and structural beams are not available for welding the cable tray mounting structure, the contractor to supply the M.S. plate and fix it to floor slab by Anchor fasteners of minimum dia. 16mm having minimum holding power of 5000 Kg.

Spacing between cable tray mounting structures to be 1000 mm for horizontal straight runs of cable trays.

Minimum loading on a horizontal support arm to be 120 kg/M of cable run.

Width of the horizontal arms of the mounting structures to be same as the tray widths required in cable layout drawings plus length required for welding to the vertical supports (maximum tray width will be 900 mm) except where shown otherwise.

The length of the vertical supporting members, for horizontal cable tray runs, will be to suit the number of cable tray tiers required in the cable layout drawings.

Spacing between horizontal support arms of vertical cable tray runs to be 600 mm.

Cable trays will be welded to tray mounting supports.

Minimum clearance between the topmost tray tier and structural member to be 300 mm.

Minimum vertical clearance below the bottom of the lowest cable tray tier and any structural member to be 300 mm.

All structural steel supplied by the contractor and exposed surface of embedded steel for cable tray mountings and shall be painted as follows:

For indoor installation one coat of red oxide zinc chromate primer and two coats of synthetic enamel paint.

For outdoor installations – painting with two coats epoxy based paint.

Where any cuts of holes are made or welding is done on finished steel work these shall be painted by the manner specified above.

Cable Trays – Construction Notes

Cable tray and the associated pre-fabricated accessories such as coupler plates, tees, elbows etc. shall be **FRP (Fibre Reinforced Plastic), 3 mm thick**.

The cable trays to be supplied in standard lengths of 2500 mm and clear inside width of trays shall be 150, 300, 450, 600 mm and 900 mm.

This requirement shall override any references to GI cable trays that might appear elsewhere in the general specifications.

Cable Trays – Installation Notes

Unless otherwise specifically mentioned, all cable tray mounting works shall be carried out as per approved drawings.

The type and size of tray to be used will be as mentioned in the individual layout drawings.

The maximum size of cable tray when used in trenches shall be of 600 mm width.

Cable trays shall be welded to the mounting/carrier structures.

Vertical trays (raceways) and all outdoor cable trays shall be provided with removable 16 gauge painted MS sheet covers.

Each continuous laid out length of cable tray shall be earthed at minimum two places by MS flats of minimum size 25 x 3 mm (unless otherwise noted) to the main earthing grid, the distance between earthing points shall not exceed 10 meters.

The following shall be checked before laying the cables on trays.

- Check for proper painting and identification nos. of the trays
- Check for continuity of power and control cable trays over the entire route.
- Check that all sharp corners, burrs and waste materials have been removed from the tray.

16.3 CABLE – INSTALLATION NOTES

16.3.1 General

These notes in general cover cables up to and including 33 KV rating.
Electrical installation work shall comply with all currently applicable statutes, regulations and safety codes in the locality/country where the installation is to be carried out.

Installation of cable shall include, unloading, storing, laying, fixing, jointing, termination, supply of glands and lugs and all other work necessary for completing the job.

Cables will be installed in trenches, trays, racks, conduits, duct banks or directly buried. The actual cable layouts will be shown on the relevant project drawings. Any changes, if necessary, after obtaining prior approval of the Purchaser/Engineer shall be carried out at site by the contractor and shall be clearly marked by him on project drawings and forwarded for approval of the purchaser.

Cable to each circuit shall be laid in one continuous length, cable jointing and splicing shall be done after obtaining Site Engineer's permission.

16.4 OUTDOOR CABLE INSTALLATION

Outdoor cables, for interplant cabling, shall be laid in built up RCC trenches, unless approved otherwise by the Engineer. Cable trays of adequate width and multi tier formation as required for cabling shall be installed in cable trenches. Adequate walkway space of minimum 600mm width shall be provided inside the cable trenches for the purpose of cable installation and future maintenance / inspection. **Adequate slope shall be provided to the cable trench bottom to drain away rain water accumulated inside the trench.** Trench top, however, shall be leveled throughout. Pre cast RCC covers with lifting facility shall be provided to cover the built up trenches.

In specific cases allowed by the engineer, cables shall be directly buried in ground as follows-

Cables laid in ground shall be laid on a 75 mm riddled earth bed. The cables shall then be covered on top and at their sides with riddled earth of depth of about 150 mm. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench shall then be backfilled with the excavated soil and well-rammed in successive layer of not more than 300 mm in depth, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, it is advisable to allow a crown of earth not less than 50 mm in the center and tapering towards the sides of the trench.

Cable route markers shall be provided at every 20 meters. At least one marker shall be provided if the length of the buried cable is less than 15 meters. Buried cables in trefoil formation shall be bound by plastic tapes of 1 mm dia. Nylon cord every 750 mm.

Joint markers at each joint location shall identify joints in directly buried cables.

In each outdoor cable run, some extra cable length shall be kept at a suitable point to enable a straight through joint to be made should the cable develop fault at a later date.

Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in RCC hume pipes of minimum length 1000mm subject to an overlap of minimum 50mm. For

road crossing, the pipe for the cable shall be buried at not less than 600 mm unless otherwise noted in the drawings.

16.4.1 Cables in Trays/on Racks

Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. H.V. cables shall be laid in top trays and cables of subsequent voltage grades in lower tiers of trays.

Minimum distance between HV & LV power cable shall be 500mm, between HV power & control cable shall be 500mm and between LV power & control cable shall be 300mm.

The sizing of cable tray shall provide a minimum of 25% spare capacity. The tray shall be run at least 150mm clear of mechanical services. All cable trays & pre-fabricated tray accessories shall be FRP only.

16.4.2 Termination Clamping and Miscellaneous Details

Cable entry to motors, push button stations and other electrical devices shall be from the bottom only.

Identification tags made from aluminium sheet shall be attached to each end of each cable by means of GI binding wire. Tags shall be additionally put at an interval of 30 meters on long runs of cables and in pull boxes.

All cable terminations shall be solder-less crimping type. The crimping tools shall be adequate for lug sizes.

All HV / LV cable terminations shall be with appropriate cable glands only.

16.4.3 Testing and Commissioning of Cables

Cables shall be checked for insulation resistance before and after jointing. The voltage rating of the meggers for cables of different voltage grades shall be as indicated below :

Voltage Grade of Cable	Megger Rating
1.1 kV	500 V
6.6 kV	1000 V
22 kV	2.5 kV Motorised Megger

16.4.4 Testing of Cable Installation

DC test voltages after installation (before commissioning) (REF IS– 1255 – 83)

DC test voltage for cables is 1.5 times rated voltage,
In each test, the metallic sheath/screen/armour should be connected to earth.

Continuity of all the cores, correctness of all connections as per wiring diagrams, correctness of polarity and phasing of power cables and proper earth connection of cable gland, cable boxes, armour and metallic sheath shall be checked.

16.5 LIGHTING

16.5.1 General

Electrical installation work shall comply with all currently applicable standards, statutes, regulations and safety codes in the locality/country where the installation is to be carried out.

Installation of lighting system shall be carried out generally as per the instructions in this document and typical drawings and relevant project layout drawings to be furnished by the contractor. For field lighting installation armoured copper cable shall be used. Lighting installation in the Pump House, DG House, Sub-station etc. shall be done with exposed cabling or exposed RS conduit and in Admin building concealed rigid PVC conduit shall be used.

The scope of installation work shall include storing, unpacking, fixing of all items associated with lighting system, laying and fixing conduits, wiring, termination, testing, commissioning and all other work items necessary for completing the job. The supply of all mounting accessories hardware, consumables like fixing saddles at the fixture fixing/suspension points, connectors, jointing ferrules, all fixing brackets, screws and studs and earthing wires shall be deemed to be included in the scope of installation work.

The scope and specification of the supply items like lighting distribution boards, lighting panels, fixtures, street lighting poles, wires/cables, conduits, receptacles, switches, ceiling fans shall be as indicated separately in schedule of items and rates.

Lighting panel, distribution boards, fixtures, fans switches, receptacles etc. shall be located as per the Purchaser's approved layout drawings. Any changes, if necessary after obtaining prior approval of the Purchaser/Engineer, shall be carried out at site by the Contractor and shall clearly marked by him on the project drawings and forwarded to the Purchaser for approval.

The required conduits for lighting wiring shall be suitably routed at site by the Contractor with due considerations to a neat layout and ease of maintenance.

Lighting panels, light control switches and receptacles shall be installed at the following mounting heights from finished floor/ground levels:

- Lighting panels – 1200 mm to bottom of the panel
- Light control switches – 1200 mm
- Receptacle units – 500 mm for indoor and 1000 mm for outdoor.

16.5.2 Lighting Panels/Distribution Boards

All lighting panels located indoor/outdoor shall be installed by the Contractor on walls/columns by fastening to suitably grouted stud.

16.5.3 Switches and Receptacles

Exact locations shall be finalized by the Contractor in consultation with the EIC or his representative.

Switches/receptacles which are to be wired on the same phase and to be located close by each other shall be accommodation / housed in the same box.

16.5.4 Conduits

Minimum size of heavy duty GI conduits used for wiring shall be of 20 mm for exposed systems. The conduits shall be supported by means of saddles as follows:

Rigid Metallic Conduits –

Spacing between saddles not to exceed 1 m in addition saddles shall be located on either ends of couplers/bonds or similar fittings/accessories. In such cases the saddles shall be located at a distance not exceeding 300 mm from the fittings/accessory.

Wires belonging to different phases shall not be run in the same conduit. However, more than one circuit, consisting of phase and neutral wires, of the same phase can be run in the same conduit, for every phase wire a separate neutral wire shall be run.

16.5.5 Wiring/Cabling

Unless otherwise stated, the mode of wiring will be as follows:

250/440V PVC insulated flexible 2 core wires used for indoor lighting wiring shall be laid in heavy duty GI conduits.

Outdoor lighting cables shall be directly buried in ground at a minimum depth 600 mm or routed in the available cable trenches. Cables crossing road/rail shall be laid in RCC hume pipes.

Size of wire shall be chosen to limit voltage drop to within 5%. Minimum area of conductor shall be 1.5 sq. mm copper, unless otherwise stated and density not to exceed 2.5A/sq.mm. Generally not more than 8 to 10 points shall be wired in one circuit. For the purpose of calculating connected loads of various circuits a multiplying factor of 1.25 will be assumed to the rated lamp wattage for mercury vapour and fluorescent lamp fixtures to take into account losses in the control gear. A loading of 100 watts and 500 watts will be assumed for single-phase 5 Amps and 15 Amps receptacles respectively.

16.5.6 Ceiling Fans

All ceiling fans shall be installed not less than 2.75 m above the floor level.

In rooms having fluorescent lamp lighting fixtures and ceiling fans, the fans shall be installed with their blades at least 100 mm above the lighting fixtures.

16.5.7 Earthing

Lighting fixtures, receptacles, switches, conduits and junction boxes shall be properly earthed using 12 SWG. GI wire (unless otherwise specified) run along the entire length of the conduit between the fixture and the corresponding lighting panel where it will be connected to the station earth.

The earth wire for each conduit length shall be efficiently fastened to the conduit at regular intervals of not more than 750 mm.

16.5.8 Testing and Commissioning

Before a completed installation or an extension to an existing installation is put into service it shall be tested as per the relevant standards/codes of practices of the country where the installation is carried out. Installation shall be tested in accordance with IS-732.

16.6 EARTHING

All electrical equipment must be efficiently double earthed in accordance with the requirement of IS 3043 and relevant regulations of Electric Supply Authority.

The earth pits shall be as per Indian Standard with proper arrangement for testing. All earthing systems, earth pits etc. to be interconnected below earth.

All earthing conductors shall be hot dip galvanized/electrolytic grade base conductor and **GI coating shall be at least 120 microns**. The main earthing rings shall be done as per practice laid in Indian Standard.

The earthing of individual electrical equipment by two distinct strips/conducted shall be done as per practice laid in Indian Standard.

The sizes of conductors for earthing various equipment shall be as follows :

Sr.	System	Earthing conductor size & Material
a)	Main Earthing Grid	50 x 6 mm MS buried under ground at a depth of 600mm below FGL.
b)	Equipment Earthing	
	6.6/0.433kV Transformer Body	50 x 6 mm GS
	6.6/0.433kV Transformer Neutral	30 x 5 mm CU
	6.6 KV and 415 V switchgear	50 x 6 mm GS
	Capacitor Control panel	50 x 6 mm GS
	Cable tray	50 x 6 mm GS
	Battery charger	25 x 3 mm GS
	Local Push Button Station	14 SWG GS wire
	Lighting Distribution Board	25 x 3 mm GS
	Lighting & Receptacle System	12 SWG GS wire
	Outdoor Street Lighting	8 SWG GS wire
c)	L.T. Motors	
	Up to 5 HP	8 SWG GS wire
	Above 5 HP & up to 15 HP	25 x 3 mm GS
	Above 15 HP & up to 50 HP	30 x 5 mm GS
	Above 50 HP	50 x 6 mm GS
d)	Earth Electrode	40 mm diameter 3000 mm long heavy duty GI pipe electrode

All electrical equipment shall be connected to the earth bus at two points except the lighting fittings and junction boxes where single earthing shall be provided. Equipment in hazardous areas shall be earthed at two places.

The contractor shall carry out soil resistivity measurement in presence of site engineer and carry out earthing system design based on soil resistivity value obtained. The test shall be carried out during the dry season. The test shall be carried out at 8 locations at least, with electrode spacing of 2m, 5m and 10m to obtain representative value of soil resistivity.

Overall earthing system resistances shall be measured and recorded in the presence of site engineer during the dry season.

Resistance of each earth electrode with electrode isolated from the system.

Combined earth resistance of the installation measured at the substation, switch room and any other point as directed by the site engineer.

The method of testing shall be as per clause 10.1 and 10.2 of IS-3043. The contractor shall prepare the test report and submit to the engineer in charge. The effective earth resistance of the system shall be less than one Ohm.

The 415V neutral shall be solidly earthed by means of two separate and distinct connections to earth using conductor of appropriate size. Each connection shall be connected to an independent earth electrode, the electrodes interconnected between themselves and the main earthing grid to form an earthing ring. The neutral earthing leads shall be kept away from the transformer tank.

Terminal joints on the equipment shall be bolted. The earthing conductors running underground shall be laid approximately 600 mm below the grade level.

Removable test links shall be provided near the earth pits to facilitate testing of earth pits.

The vessels shall be earthed at two points.

The vessels to be earthed shall be connected to a common earth grid of power system.

For equipment earthing, suitable GI bolts with spring and plain washers to suit the thread of earth boss of vessels etc. shall be provided.

16.6.1 Earth Pits :

The number of earth pits will depend upon soil resistivity and the voltage of the system. The earth pit together with the electrode shall be constructed as per IS 3043 – 1987. The minimum distance between two earth pits shall not be less than twice the length of the electrode. A bolted assembly link shall be provided in the connection between earth electrode and the main earth conductor. GI pipe for watering shall be included in the earth pit.

16.6.2 Earth Bus and Earth Wires :

Framework and other non-current carrying metal work association with each system e.g. transformer, tanks, switchgear frame work etc. shall be earthed. Extraneous metal framework

not associated with the power system. E.g. boundary fence, steel structure, sheaths of communication cables etc. will have to be earthed.

Each incoming and outgoing cable shall be bound to the switchboard earth so that the armour and sheathing with feeders and interconnection shall form an earth system. The complete earthing system inside a substation shall be given a coat of black asphaltic varnish.

16.6.3 Earthing of Distribution Boards, MCCs etc:

Distribution boards and MCCs shall be provided with two visible, separate and distinct earth connections from the ring main.

A separate earth bar shall be provided throughout the length of the MCC or distribution board, and individual connections to various items of equipment in the distribution board or MCC shall emanate from the above bus bar in the form of a ring.

16.6.4 Earthing of motors, starters and push buttons:

All the motors shall be provided with separate and distinct earth connection from ring main. Where the terminal box is not part of the motor frame or where a sealing box is used, a bond shall be provided from the gland plate or armour clamp to the motor frame. Starters and push buttons shall be double earthed.

16.6.5 Testing of earthing system:

Resistance of all earth electrodes and total resistance of each group shall be tested to prove that the value do not exceed that specified in the codes of practice or regulations and recorded. Earth pit resistance shall not be more than 1 Ohm.

The continuity of earthing and resistance of each earthing connection to the equipment shall be tested and recorded.

16.7 FABRICATION WORK

M.S. channels/angles of requisite size shall be used for cable tray supports/push button station mounting frames, panel frames etc. The fabricated work shall be provided with two coats of zinc rich red oxide primer & 2 coats of enameled paint of approved colour. The scope of fabrication work includes supply of necessary hardware viz. anchor fasteners, M.S. base plate etc.

16.8 SAFETY EQUIPMENTS

Following safety equipments shall be provided at the specified locations:

1. Sand Bucket Extinguishers:

Two sand buckets of adequate capacity shall be installed in the transformer rooms at approachable location.

2. Dry CO₂ Fire Extinguishers:

Dry carbon dioxide type portable fire extinguishers, of minimum 5 kg capacity, shall be provided in each panel room.

3. Insulating Anti-skid Rubber Mats:

11 kV grade anti-skid rubber mats shall be provided in front of 6.6kV switchgear panels throughout the length of the switchgear.

1.1 kV grade anti-skid rubber mats shall be provided in front of all LT switchgear throughout the length of the switchgear.

4. Shock Treatment Charts

2 nos. Shock treatment charts in English & local language as per relevant standards shall be provided in each panel room at an approachable location.

5. Danger Plates

"DANGER" plates indicating relevant voltage grade written in English and local language shall be provided at all accessible sides of the following location.
6.6kV Switchgear room, Transformer rooms and all LT panel rooms.

6. A set of 11 kV grade hand gloves and earthing rods.

16.9 TESTING

Following testing shall be carried out at site after installation of electrical equipment, as a part of pre-commissioning testing.

A) 6.6 kV Switchgear (Both Pump and DG)

- i. Insulation Resistance measurement (with 2.5 kV IR Tester for power circuit and with 500 V IR Tester for control circuit)
- ii. Functional checks including interlock testing.
- iii. Testing of relays at their recommended settings and other protective devices to ensure reliable operation.

B) 250 kVA Auxiliary Transformer

- i. Measurement of winding resistance
- ii. Measurement of Voltage Ratio.
- iii. Checking of Phase Displacement.
- iv. Measurement of Short circuit impedance and load loss.
- v. Measurement of No-load loss and Current.

C) 415 V Switchgear

- i. Insulation Resistance measurement with 500 V IR Tester.
- ii. Functional checks including interlock testing.

D) 415 V APFC equipment

- i. Insulation resistance measurement with 500 V IT Tester
- ii. Measurement of 3 phase currents of all capacitor units
- iii. Manual and Auto operation of control scheme

- E) 6.6 kV Soft Starters
 - i. Insulation Resistance measurement (with 2.5 kV IR Tester for power circuit and with 500 V IR Tester for control circuit)
 - ii. Functional checks including interlock testing by simulation where required.
- F) Power and control cabling
 - i. Insulation Resistance measurement with 2.5 kV IR Tester for 6.6 kV cables and 1.0 kV IR Tester for LV power and control cables.
 - ii. Continuity check.
- G) 6.6 kV NGR (Neutral Grounding Resister)
 - i. Insulation Resistance measurement with 2.5 kV IR Tester
 - ii. Resistance Measurement (compare with factory test reports)
- H) 6.6 kV Neutral Isolator Panel
 - i. Insulation Resistance measurement with 2.5 kV IR Tester
 - ii. Functional checks including interlocks testing
- I) Earthing System
 - i. Measurement of overall earthing grid resistance.
- J) Lighting System
 - i. Correctness of circuit allocation
 - ii. Measurement of lux levels
- K) 110 V Battery
 - i. Charge – discharge testing
- L) Battery Charger
 - i. IR measurement
 - ii. Functional and operational checks under Float and Boost mode conditions.
 - iii. Simulation of all abnormal conditions for alarms
 - iv. Setting of Float and Boost mode voltages and current limits.
- M) Main Pump Motors
 - i. IR measurement with cables included, with 2.5 kV IR Tester.
 - ii. Simulation of safeties and functioning of MAPE unit.
 - iii. Direction of rotation.
 - iv. No load current (compare with factory test certificate)
- N) LV Motors
 - i. IR measurement with 500 V IR Tester.
 - ii. Direction of rotation.
 - iii. Winding resistance measurement (compare with factory test certificates)
 - iv. No load current (compare with factory test certificates)

17 LIST OF RECOMMENDED MANUFACTURERS / MAKES FOR ELECTRICAL EQUIPMENT AND INSTRUMENTS

Sr.	Equipment	RECOMMENDED MAKES
A	6.6 kV HV – ELECTRICAL SYSTEM	
1	6.6 KV Switchgear Panel	ABB / SIEMENS / CGL/ Jyoti
2	6.6 KV CTs & PTs	Prayag / Pragati / Kappa / ECS / Silkaans
B	Distribution Transformer	PACTIL / AE / INDCOIL
C	TRANSFORMER ACCESSORY	
1	H.V. Bushing	W.S. / CJI / Modern
2	L.V. Bushing	W.S. / CJI / Modern
3	Neutral Bushing	W.S. / CJI / Modern
4	WTI, OTI	Perfect Controls
5	MOG	Sukrut Udyog
6	Buchholz Relay	ATVUS
7	Pressure Relief Valve	Sukrut
E	NGR	National Resistors / Tefco
F	LV – ELECTRICAL SYSTEM	
1	LV Switchgear Panel	L & T / SIEMENS / Schneider / Elecmech / Elma / Hitec
2	Moulded Case Circuit Breakers	L & T / SIEMENS / ABB /ALSTOM / Schneider
3	Motor Protection Circuit	L&T / ALSTOM / SIEMENS / ABB / Schneider
4	Contactors AC / DC	L&T / ALSTOM / SIEMENS / ABB/ Schneider
5	Thermal O/L relay	L&T / ALSTOM / SIEMENS / ABB / Schneider
6	Current / Potential Transformer	KAPPA / Indcoil / Precise
7	Power Capacitors	MALDE / L & T (MEHER) / ASIAN / SIEMENS
8	Protective relays Numerical Measurement + Auxiliary (Electro magnetic & static)	ALSTOM / ABB / SIEMENS / L&T / ALSTOM / ER
9	Cables HT Cable LT Cable	CCI / FORT GLOSTER / POLY CAB / TORRENT / ASIAN (RPG) / UNIVERSAL
10	Cable Gland	COMET / BRACO / SIEMENS
11	HT Cable Termination	RAYCHEM / MAHINDRA / CCI
12	Lugs	DOWELL / 3D / BRACO
13	Indicating Meters	MECO / RISHABH (L&T)/ AEP / IMP

Sr.	Equipment	RECOMMENDED MAKES
G	COMMON ITEMS	
1	Sealed Maintenance Free Batteries	AMCO / SABNIFE / STANDARD BATTERIES/ AMAR RAJA / EXIDE / GLOBAL
2	Battery charger	SABNIFE POWER SYSTEMS / CHHABI ELECTRICALS PVT. LTD. / HANSA ELECTRONICS / AE/ AFCO
3	Indicating lamps	L&T / SIEMENS / ALSTOM/ TEKNIC
4	Terminal blocks	ELMEX / WAGO (C&S)
5	Lighting Fixtures– non flameproof	PHILIPS / WIPRO / BAJAJ / CGL
	Lighting Distribution Boards	MDS / ABB / SIEMENS / HAVELLS
6	Miniature Circuit Breakers	MDS / L & T / SIEMENS / S & S/ABB
7	Annunciators	MINILEC / BEACON / ICA
8	Energy Meters	ELECTRONIC: ENERCON / L & T / ALACRITY ELECTROMECHANICAL: GEC-A / SIMCO / IMP
9	Electronic Multi-function meter	ENERCON / L&T / Schneider
10	Breaker Control / Selector switches	EE / KAYCEE / SIEMENS / JYOTI
11	Current, Voltage and Power Traducers	ABB / APEX ELECTRICALS / MECO / AE
12	START-STOP Push Button Stations	L&T / SIEMENS / HANSU / TEKNIC
13	Uninterrupted Power Supply (UPS)System	Tata Liebert / Reliance / APC / Merlin Gerin
14	Flameproof Equipment (Local Push Button Stations, Lighting Fixtures, JBs, cable glands etc)	FCG / Flexpro / Sudhir Switchgear / Baliga
15	Motors – Non flameproof	Crompton Greaves / Bharat Bijlee / Siemens / Kirloskar Electric
16	Motors – Flameproof	Crompton Greaves / Kirloskar Electric
H	INSTRUMENTS	
1	PLC	Schneider / Allen Bradley / Mitsubishi
2	Level Instruments	Siemens / E & H / Forbes Marshall

Successful bidder can propose for alternative makes in Electrical equipment / instruments by adopting procedure mentioned in Volume 2, Section 2C, pg. 84 & 85.

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**TECHNICAL SCHEDULES (TO BE FURNISHED BY
CONTRACTOR WITH BID)**

Refer Section 2G for datasheets.

19 INSTRUMENTATION AND CONTROL SPECIFICATIONS

PART A: GENERAL INSTRUMENTATION CONTROL AND AUTOMATION REQUIREMENTS

19.1 INTRODUCTION

The general requirements include design, manufacture, testing at works, supply and delivery at site, unloading and storing the equipment at site of installation, testing and commissioning of all Instrumentation ,control and automation equipment's are covered under this section of this Specification.

19.2 ABBREVIATIONS

For the purpose of these Requirements the following abbreviations of electrical terms have been used.

Symbol	Abbreviations	Symbol	Abbreviations
R	red phase	MCB	miniature circuit breaker
Y	yellow phase	MCCB	moulded case circuit breaker
B	blue phase	ELCB	earth leakage circuit breaker
ac	alternating current	RCD	residual current device
dc	direct current	MCC	motor control centre
A	Amp	PFC	power factor correction
mA	Milliamp	PF	power factor
V	Volt	CP	control panel
kW	Kilowatt	LCP	local control panel
kVA	kilovolt amp	UPS	uninterruptible power supply
kWh	kilowatt hour	PLC	programmable logic controller
MVA	megavolt amp	I / O	input / output
Hz	hertz (cycles per second)	R I / O	remote input / output
SP	single pole	SCADA	supervisory control and data acquisition
SPN	single pole and neutral	HMI	human machine interface
DP	double pole	LAN	local area network
TP	triple pole	OS	operator station
TP&N	triple pole and neutral	PC	personal computer
SP&SwN	single pole and switched neutral	SPD	surge protection device
TP&SwN	triple pole and switched neutral	LED	light emitting diode
FOC	fiber optic cable	UHF	Ultra High Frequency

19.2.1 Instrumentation Earth

An instrumentation earth bus shall be provided in each control panel. This shall comprise a GS flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the control panel electrical power earth. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection to the same point as before on the control panel electrical earth bar. In this fashion all instrument earths shall be connected radially from the same earth point.

All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

Surge protection devices (SPD's) associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

19.3 CABLES AND WIRES

19.3.1 General

Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, cable size, number of cores, length, result and date of tests as required in the Employer's Requirements.

Cables manufactured more than 12 months before delivery shall not be accepted.

All cables shall be delivered with cable ends effectively sealed. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture.

Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Contractor shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.

Cables shall be stored at site in storage yard wherein the same is protected by sunlight & moisture

19.3.2 Applicable Standards

a) Low voltage (650/1 100 V grade)

XLPE/F/PVC or XLPE/W/PVC or PVC/W/PVC or PVC/F/PVC, multicore cable with aluminium conductors to IS 7098 part 1, IS 1554 or BS 6346 respectively. Installed direct in the ground, in ducts, on tray or clipped direct. Aluminium wire armouring shall be used for single core cables. Core identification shall be by printed numerals or colour.

b) Low voltage (650/1 100 V grade)

PVC/PVC multicore cable to IS 1554 or BS 6346. Installed in floor ducts, trunking or conduits.

PVC single core non-sheathed (450/750 V grade) to BS 6004. Installed in conduit or trunking.

PVC single core non-sheathed (600/1 000 V) to BS 6231. Installed as internal wiring within switchgear and control assemblies.

c) Telecommunications

19.3.2.1.1 External Use

The cable shall be cellular polyethylene insulated armoured telephone cable manufactured generally in accordance with Indian Department of Telecommunications Specifications. The conductors shall be 0.9 mm diameter copper. The insulated conductors shall be twisted together in pairs and shall be identified by colour. The cable shall be fully filled with tropical grade petroleum jelly and a polyethylene sheath shall be applied over the laid up pairs. A layer of galvanised steel wires shall be applied over this sheath.

A black coloured PVC or polyethylene sheath shall be applied overall.

Installed in ducts, pipe ducts and direct in the ground.

19.3.2.1.2 Internal Use

The cable shall have tinned copper conductors of 0.5 mm diameter with PVC insulation and PVC oversheath. It shall comply generally with Indian Department of Telecommunications Specifications.

The colour of the sheath shall be cream.

For use indoors for internal distribution and connection to extension instruments. Installed in conduit, trunking or clipped direct.

d) Instrumentation

19.3.2.1.3 Analogue Signal Plain annealed multi stranded tinned copper conductors; solid polyethylene insulation with each pair screened with aluminium-mylar tape including drain wire, with collective aluminium mylar tape screen including drain wire, solid polyethylene bedded steel wire armour with an outer sheath of flame retardant PVC. PVC sheath to be blue colour for intrinsically safe circuits, black for ac and dc non-intrinsically safe circuits, 600 V grade to BS 5308 : Part 1, Type 2, IS 1554 or IEC 189.

19.3.2.1.4 Control Digital

19.3.2.1.5 Plain annealed multi stranded tinned copper conductors, solid polyethylene insulation collective aluminium mylar tape screen including drain wire, solid polyethylene bedded steel wire armour with an outer sheath of flame retardant PVC. PVC sheath to be blue colour for I ntrinsically safe circuits, black for ac and dc non-intrinsically safe circuits, 600 V grade to BS 5308 : Part 1, Type 2, IS 1554 or IEC 60189.

e) SCADA System

Redundant Fiber optic cable and network shall be applied to the SCADA system to integrate PLCs and RIO's located in the plant and the work stations located at the control room. FOC shall be single mode, glass made core and clad and PVC covered with tension member, jelly filled and PVC sheathed. Maximum attenuation of OFC shall be 0.4 dB/km and 0.3 dB/km at 1310nm and 1550nm wave length light respectively. Datasheets for the same shall be submitted for review and approval.

19.3.3 Cable Rating

The Contractor shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use.

In assessing the rating of any cable or wire, the following factors shall be taken into account:

- Supply voltage and frequency
- Maximum voltage drop permissible
- Type and magnitude of load
- Fault level and duration related to circuit protection relays and MCB/MCCBs
- Circuit overcurrent protection
- Route length and disposition of cables
- Ambient temperature
- Method of installation

19.3.4 Cable Colours

All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

The colour coding should be as follows:

3 phase	red, yellow and blue
single phase or dc	red and black
earth	green/yellow
control	blue (dc), red (ac)

19.3.5 Cable Conductors

Copper conductors shall be used throughout. Cores of cross-sectional area greater than 1.5 mm² shall be stranded.

Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm². Small power and control cables shall be of a minimum cross-section of 1.5 mm².

Internal wiring of control panels shall be of a minimum cross-section of 1.0 mm² flexible and stranded.

Instrumentation and control cabling shall be of a minimum cross-section 1.5 mm² for external use and 1.0 mm² for internal use.

19.3.6 Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three digit number.

HV power	HV-P_ _ _
LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _
Telecommunication	T_ _ _

19.4 CABLE INSTALLATION

19.4.1 General

Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.

Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.

All cables shall be laid with minimum looping of 1 metre in the pull pits on either end.

Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference.

The following Table details the distances in mm that shall be maintained between the different categories of cable.

Cable Category	HV Power	LV Power	C&I/Protection	Telecommunications
HV Power	N/A	300	600	600
LV Power	300	N/A	300	300
C&I/Protection	600	300	N/A	100
Telecommunications	600	300	100	N/A

These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.

In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.

Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.

Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation of 150 mm shall be maintained between power and non-power cables when run on the same support system.

Heavy duty galvanised iron cable tray and ladder racking shall be used for cable support systems. GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

19.4.2 Instrumentation Cabling

In order to make the most economic use of cable ladder/tray and duct capacity, multicore cabling shall be utilised in order to connect instrumentation groups by using suitably located sub-distribution junction boxes. The junction boxes shall be suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labelled junction boxes shall be constructed of die cast aluminium and provide degree of protection IP 65.

Separate cables shall be used for digital and analogue signals at all times.
Instrumentation cables shall be continuous without any joints.
Digital and analogue signals shall be segregated within junction boxes.

19.4.3 Cables Laid Direct in Ground

Buried cable up to 650/1100 V shall have a minimum cover of 750 mm measured to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete.

Cables of greater than 650/1 100 V shall be buried with a minimum cover of 1 m. The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable.

Interlocking cable protective covers, minimum 1 m long x 300 mm wide, marked 'Danger - Electric Cable' in English and the vernacular shall be laid on top of the sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm.

Warning tape shall be laid a minimum of 200 mm above the protective covers.

Cables are to be installed without tees or through joints unless otherwise approved by the Engineer. Single core cables shall be run in trefoil formation.

19.4.4 Cables Laid in Underground Ducts

Underground ducts shall be constructed of impact resistant PVC-U and laid at a minimum depth of 500 mm, ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1 m deep and encased on all sides by 150 mm of concrete.

The Contractor shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required. All cables shall be laid with minimum looping of 1 metre in the pull pit on either ends of the cable.

Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated. RCC duct bank shall be provided wherever there is road crossing.

19.4.5 Cables installed in Conduit

f) General

Conduits shall be galvanised heavy gauge solid drawn or welded screwed steel type and be in accordance with IS 9537 Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanised.

A space factor of 40% shall not be exceeded, but in any case conduit of less than 20 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.

Where a number of conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.

Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.

Heavy hexagonal lock nuts shall be used at all positions where running joints are required and great care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Engineer. Where terminal blocks are necessary, they shall be of the porcelain type with brass pinching screws.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc. and covers, either temporary or permanent, shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.

g) Surface Installation

Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips which allow the conduits to be taken directly into accessories

without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Engineer before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanised cable trunking. Conduits installed on structural steelwork shall be secured at spacings not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Engineer. Any drilling or access which is required through any structural member of the building shall be agreed with the Engineer before carrying out the work.

Exposed threads and places where galvanising has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

h) Concealed Installation

Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crampets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.

At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

The conduit installation shall be inspected by the Engineer before the building operation conceals the work.

i) Cable Installed in Flexible Conduit

Flexible conduit shall be of the waterproof galvanised type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

19.4.6 Cable Installed in Cable Trunking - Metal

Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanised. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50 mm x 50 mm minimum size.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.

The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self retaining 'quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2 m horizontally or 2.5 m vertically.

Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanising paint.

Cable and conduit/trunking runs shall be determined by the Contractor and agreed by the Engineer before any work is started. The run shall be at least 150 mm clear of plumbing and mechanical services.

Conduit/trunking systems erected outside a building shall be weatherproof.

19.4.7 Cable Installed on Cable Tray

Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1 mm for trays up to 100 mm width, not less than 1.25 mm for trays from 100 mm to 150 mm width and not less than 1.5 mm for trays from 150 mm to 300 mm width.

Cable tray shall be hot dipped galvanised. Cable tray for use in areas where chlorine gas may be present shall constructed from FRP or GRP. Cable tray supports shall be of a compatible finish with the associated cable tray.

All cable tray tees, intersection units, bends, turns and sets shall, whenever possible, be purpose made by the manufacturer and shall be of a matching design to the main section of cable tray.

Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturers instructions.

Cable tray supports supplied by a manufacturer or made up on Site shall be of ample strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at midspan.

Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, then for galvanised trays, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanised paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.

All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Engineer, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at midspan. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kg.

Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray. The sizing of the cable tray shall provide a minimum of 30% spare capacity.

The tray shall be run at least 150 mm clear of plumbing and mechanical services.

19.4.8 Cable Installed on Ladder Rack Systems

Ladder racking either light or heavy weight shall be proprietary item and installed in accordance with manufacturer's instructions. Bends in the installation shall take account of the minimum bending radii of cables to be installed.

Cables shall be clipped to the ladder rack using clips designed for the system in use and appropriate to the type and size of cable installed.

The sizing of the cable rack system shall provide a minimum of 30% spare capacity. The ladder racking shall be run at least 150 mm clear of plumbing and mechanical services.

19.4.9 Cable Clipped Direct

All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed.

Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

19.4.10 Cable Installed in Internal Floor Trench

j) In Shallow trenches (maximum depth 500 mm)

In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an approved manner.

Where the trench is shared by other services, cables shall be installed on the walls of the trench in an approved manner.

k) All other trenches including walk through service ducts

Cabling shall be installed to the walls of the trench in an approved manner.

Where other services are present the cables shall be segregated from them and wherever possible kept above 'cold' wet services. Cables should not be run if at all possible above or in close proximity to 'hot' services. The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation

19.4.11 Cable Terminations and Joints

l) Power Cable Terminations

Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors.

Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.

Adequate provision shall be made to bond the cable armouring to the box and/or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box is not possible.

Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.

Where terminations of multicore type have to be made on to items of Plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.

Where single core cables are glanded to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

m) Power Cable Joints

Through joints shall only be allowed with the approval of the Engineer. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and prepacked ready for use. The boxes shall preferably be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Engineer prior to filling the box with compound. Wrapped pressure type joints will not be accepted.

19.4.12 Multicore or Control Cable Terminations

A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.

Terminals which remain energised when the main equipment is isolated shall be suitably screened and labelled.

Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labelled.

19.4.13 Cable Fixings

Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing.

Large single cables shall be secured with cable clamps or cable cleats.

19.4.14 Cable Identification

At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Engineer. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

19.4.15 Cable Glands

Glands shall generally be of the mechanical compression hexagon type. Earth continuity of brass glands shall be assured. This may be achieved by the rigid clamping of the armour within the gland and the intimate contact between the threaded components of the gland and the equipment. Each gland shall be installed complete with proprietary earth tag providing a ready means of connecting a flexible strand or strip earth bond to the gland at any position around the gland in relation to the associated apparatus. Adequate earth continuity shall be assured between the earth tag, the gland and the armour wires of the cable where applicable.

Glands for single core cables shall be constructed from non-magnetic materials.

Each gland shall be installed complete with a proprietary non-ferrous lock-nut to secure the gland body to the equipment where the entry hole is plain, i.e. not tapped.

Where holes for cable entries are not provided it shall be the responsibility of the Contractor to mark out and drill such holes. Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.

For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used and entry shall be sealed.

For dry indoor situations, standard industrial glands with shrouds are acceptable.

For hazardous areas, glands conforming to EExd standard shall be used with double seal and shroud.

Power cable glanding arrangements in hazardous areas shall incorporate an insulated adapter and earth link. This shall provide the facility to disconnect the armouring from the ganged device in order that a true earth loop value may be measured when carrying out tests on the installation.

19.4.16 Marking Locations of Underground Cables

The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.

In addition concrete marker posts shall be installed at intervals of not more than 50 m at all junctions and changes of direction along the cable route. Such marker posts shall be not less than 200 mm high and of substantial construction. A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer.

The markers shall be marked 'Instrumentation /Telecommunication cable' in English and the vernacular.

PART-B GENERAL REQUIREMENTS INSTRUMENTATION CONTROL & AUTOMATION

19.5 INTRODUCTION

This part covers the general requirements for the design, supply, installation, inspection and testing of the instrumentation, Control & Automation and associated plant and materials.

19.6 REFERENCE STANDARDS

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

BS 89-2:1990, EN 60051-2:1989, IEC 60051-2:1984	Direct acting indicating analogue electrical measuring instruments and their accessories.
BS 1042 (Various)	Measurement of fluid flow in closed conduits.
BS 1646-1:1979, ISO 3511/I-1977	Symbolic representation for process measurement control functions and instrumentation. Basic requirements
BS EN 837-1:1998	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
BS EN 60751:1996, IEC 60751:1983	Industrial platinum resistance thermometer sensors
BS 3680 (Various)	Measurement of liquid flow in open channels.
BS 3693:1992	Recommendations for design of scales and indexes on analogue indicating instruments
BS EN 60770-1:1999, IEC 60770-1:1999	Transmitters for use in industrial-process control systems. Methods for performance evaluation
BS 4675-2:1978, ISO 2954-1975	Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity
BS EN 60584-1:1996, IEC 60584-1:1995	Thermocouples. Reference tables
BS 5308 (Various)	Instrumentation cables
BS EN 60529:1992	Specification for degrees of protection provided by enclosures (IP code)
BS ISO 11631:1998	Measurement of fluid flow. Methods of specifying flowmeter performance
BS 5863-1:1984, IEC 60381-1:1982	Analogue signals for process control systems. Specification for direct current signals
BS 5863-2:1980, IEC 60381-2:1978	Analogue signals for process control systems. Specification for direct voltage signals
BS EN 60654-1:1993, IEC 60654-1:1993	Industrial-process measurement and control equipment. Operating conditions. Climatic conditions
BS 6739:1986	Code of practice for instrumentation in process control systems: installation design and practice
BS EN 60073:2002	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators
BS 1553 (Various)	Specification for graphical symbols for general engineering
ISA-5.1-1984 - (R1992)	Instrumentation Symbols and Identification
ISA-5.4-1991	Instrument Loop Diagrams

ANSI/ISA-7.0.01-1996	Quality Standard for Instrument Air
ANSI/ISA-18.1-1979 - (R1992)	Annunciator Sequences and Specifications
ISA-26-1968	Dynamic Response Testing of Process Control Instrumentation
ISA-37.1-1975 - (R1982)	Electrical Transducer Nomenclature and Terminology
ISA-37.3-1982 - (R1995)	Specifications and Tests for Strain Gage Pressure Transducers
ANSI/ISA-50.00.01-1975 (R2002)	Compatibility of Analog Signals for Electronic Industrial Process Instruments
ANSI/ISA-51.1-1979 - (R1993)	Process Instrumentation Terminology
ISO 9000 and 09004	Quality Systems
IEEE 60587	Power Supply Surge Protection
IEC 61131-3	Programming Languages for Programmable Controllers.
IEC 61158-2	Communication Protocols
ISO 9075 (BS 6964)	Structured Query Language (SQL)
BS 5515	Documentation of Computer Based Systems
BS 7165	Recommendation for Achievement of Quality in Software
BS EN 50081	Electromagnetic Compatibility
ISO 3511	Process measurement control functions - instrumentation symbolic representation.
ISO-OSI	7 Layer Communication Model
IEEE 472-1974	Surge protection.
IEC-61850	Sub-station automation protocol
IEC-8705101	Modbus Protocol Conversion

19.6.1 Statement of Compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during the FDS submission once the contract has been awarded.

All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Engineer for consent before any design against that standard proceeds.

19.6.2 Documents to be submitted by the Bidder during Bid Submission

Note: The technical schedule shall be completed in full for technical bid qualification. Bidder to note the importance of this requirement.

1. Provide a block diagram of the proposed system showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces.
2. Provide a written overview of the proposed control & instrumentation system describing the principal functions and capabilities of the system (PLC based SCADA), system communications, pump performance & monitoring system and general system capabilities.

3. Provide an equipment list with descriptive literature for the proposed system. Included on the list shall be all hardware & software items. List shall include as a minimum, the manufacturer, the quantity provided, and model numbers for each. Technical schedules for instruments, PLC & SCADA, shall be duly filled with all relevant details without any deviations with the bid requirements.
4. Provide an operating system and software applications list with descriptive literature for the proposed system. Include all major software items, supplier name, quantity, and model numbers. Indicate whether any proposed software is proprietary and would not be turned over to the owner.

Note: Proprietary software will not be accepted.

5. Technical details are required for the following without any deviation as per bid requirements:
 - Name and version of the proposed SCADA software Package.
 - Name and version of the PLC on-line/off-line programming software for all controllers, inclusive of vendor supplied systems (if any).
 - Name and version of the PLC,
 - Name and version of any required communications software, firmware, etc.
 - Name and version of the specified report application software,
 - Provide a description of any non-resident software required to program, troubleshoot or diagnose any devices in the system.
 - Provide a tentative construction schedule for completion of the project within the specified Contract period. Indicate the following activities with milestones: Mobilization, submittal preparation, submittal review, equipment procurement, equipment assembly, system configuration and programming, factory testing, system delivery, system installation, start up, field testing and training, and post acceptance routine service intervals.

The Contractor shall provide all of the above required details/documents as qualification criteria during the bid submission.

19.6.3 Qualification Criteria for Instrumentation vendor, Integrator and Automation vendor, Integrator, and Pump conditioning & Monitoring system.

All vendors/integrators shall be operating under an accredited ISO 9001-2015 or above Quality System on a minimum.

The contractor shall submit the credentials of the system integrator proposed, for approval of the Employer Representative, before commencing any design or works.

Instrumentation:

The Instrumentation system integrator on a minimum shall be operating under an accredited ISO 9001:2015 systems.

The instrumentation system integrator should have minimum 10 years of experience in India in the field of instruments supply, installation, commissioning and operation and maintenance of instruments in plants as required under this contract and shall demonstrate capability and resources for integrating/interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution. The instrumentation system integrator shall be an authorized channel partner for the instrumentation equipment for not less than five years. Verification certificates signed not less than the country head of OEM shall be submitted.

The instrumentation system integrator shall have executed & completed at least three individual projects of minimum 100 MLD capacity Water Pumping Station during the last ten years period, inclusive of supply, installation, commissioning and operation and maintenance period of minimum 1 year in the last ten years. The agency shall have minimum five number of design engineers with at least five years of relevant experience in design, installation and Commissioning of works similar to this contract and capacity. The engineers shall be on its permanent employment. Proof of ESIC/PF should be submitted to demonstrate the permanent employment. (Associate Employer Representatives/ Advisers/ consultants shall not be considered).The agency shall submit documentation and signed resumes of the personnel as part of credentials submission.

Control & Automation:

The Automation system integrator on a minimum shall be operating under an accredited ISO 9001:2015 system with a minimum of 15 years' experience of having designed, executed & completed SCADA projects (PLC based SCADA system) inclusive of supply, installation and commissioning; and operation and maintenance period of minimum 1 year on a single facility within India during the last five years and shall demonstrate capability and resources for integrating/ interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution.

The Automation system integrator (agency) must be an authorized channel partner for the named PLC hardware & SCADA software for minimum of 5 years on a continuous basis till date. Verification certificates signed not less than the country head of OEM shall be submitted. The agency proposed personnel shall be trained on a yearly basis by the product OEM on the proposed control system. Agency shall submit documentation for the same as part of credentials submission.

The system integrator shall demonstrate in house FAT facility with FAT simulation panel and other required hardware and software to conduct FAT as required under this contract. Agency shall submit documentation for the same as part of credentials submission

The Automation system integrator shall have executed & completed at least three individual contracts of minimum 100 MLD Water Pumping Station automation within India during the last ten years period, inclusive of supply, installation, commissioning and operation and maintenance period of minimum 1 year in the last ten years.

Note: The Automation system integrator (agency executing the works) shall have a Automation manager with minimum fifteen years of relevant experience and at least two team leaders with minimum seven years of relevant experience. The agency shall have minimum five number of design engineers with at least five years of relevant experience in design, installation and Commissioning of works similar to this contract and capacity. The engineers shall be on its permanent employment. Proof of ESIC/PF should be

submitted to demonstrate the permanent employment. (Associate Employer Representatives/ Advisers/ consultants shall not be considered).The agency shall submit documentation and signed resumes of the personnel as part of credentials submission.

19.7 SUBMISSIONS TO BE MADE BY THE CONTRACTOR DURING THE CONTRACT PERIOD:

- 1) The Contractor shall make submissions to the Employer Representative of all design drawings, schedules and complete documentation on spare parts relating to instrumentation and control equipment and systems provided under this Contract.
- 2) These submissions shall include, the following:
 - Functional design specification (FDS) The Contractor shall submit a complete functional Design specification (FDS) for approval by the Employer Representative within five (5) months of the award of the Contract. The Contractor should take note of the importance of this clause.
 - The functional design specification shall be submitted for the following:

A. Instrumentation

- a) Instrument schedule with process ranges and instrument range, and instrument model numbers
- b) The FDS shall include on a minimum, Instrument location layouts, Instrument datasheet, OEM product brochure, Instrument hook up diagrams and quality Assurance plan for inspection at manufacturer's test and quality facility where the equipment has been manufactured, as required under bid requirements.
- c) General arrangement drawings of field-mounted instruments showing installation details.
- d) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
- e) Layout drawings of panel fascias showing instruments, controls and details of all labels.
- f) Internal circuit and wiring diagrams for instrument and control panels.
- g) Schematic control diagrams.
- h) Instrument loop diagrams.
- i) Instrument wiring and piping diagrams.
- j) Interconnection wiring diagrams.
- k) Cable block diagrams, drawings and schedules.
- l) Instrument system and panel power distribution diagrams.
- m) The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.
- n) The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
- o) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.

B. Control & Automation

- 1) This document shall serve as the primary mechanism by which the Employer Representative may confirm that the Contractor possesses an accurate understanding of the system and its control requirements.
 - a) On a minimum, FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. Flow charts shall be used to depict the control philosophy along with the write up for the same.
 - b) Proposed SCADA screens, set point schedules, shall be an integral part of the FDS submissions.
 - c) The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal.
 - d) The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.
 - e) The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
- 2) Drawings and schedules as part of FDS (For both Instrumentation & Control & Automation):
 - a) Process and instrumentation diagram (P&ID) shall be as per ISA 5.1 latest release. The P&ID shall contain the following on a minimum and in sequence:
 - 1) Legend sheet inclusive of process line abbreviations, line designation, process designation, symbols of all equipment and general notes.
 - 2) Tag Identification system. (The tagging philosophy shall be submitted before the submission of the P&ID for review and approval before the tagging is incorporated in the P&ID).
 - 3) Typical Signal interface sheet
 - 4) Process & Instrumentation sheets as per each process, which shall depict the interlock sequence for each equipment & process operation. The interlock sequence shall be depicted by using interlock numbering next to the equipment/process.
 - 5) Interlock sheet detailing every interlock for the system (Pumps, drives, valves, etc.). For e.g.: Start, Stop, Trip, sub process sequence, etc.
 - 6) Each P&ID shall be submitted along with the process control philosophy.
 - b) General arrangement drawings of field-mounted instruments showing installation details.
 - c) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
 - d) Layout drawings of panel fascias showing instruments, controls and details of all labels.
 - e) Layout drawings of panel interior showing equipment, terminal blocks and cable ways.
 - f) Annunciator arrangement and engraving details.
 - g) Internal circuit and wiring diagrams for instrument and control panels.

- h) Schematic control diagrams.
 - i) Instrument loop diagrams.
 - j) Instrument wiring and piping diagrams.
 - k) Interconnection wiring diagrams.
 - l) Cable block diagrams, drawings and schedules.
 - m) Instrument system and panel power distribution diagrams.
 - n) Programmable-device functional design specifications which shall include hardware details, logic flow charts, panel GA, panel wiring diagrams, ladder diagrams and program listings.
 - o) Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
 - p) Labelling & tag schedules.
 - q) Communication details ,data transfer between pumping stations and centralized monitoring station.
 - r) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.
- 3) All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels and the like and for the complete understanding of the operation, maintenance and extension of the system including any required for the Purchaser to dismantle, repair, maintain, modify or extend the Plant.
- 4) Control room, RIO Room interior design layouts, interior design diagrams, control room wiring layout, access control point diagrams, to house the PLC based SCADA system, LED video wall, integration panels, etc.
- 5) Control room shall be designed for complete view of the pumping system facility with glass walls and shall be with false flooring and false ceiling system with minimum 2 nos of 2 tonnes air conditioning system to main the temperature in the control room.
- 6) Data and calculations
- a) Manufacturers' catalogues and data sheets.
 - b) Calculations to support control system design.
 - c) Specification for protective coatings and painting.
- 7) Certificates
- a) Manufacturers' works tests.
 - b) Pre-installation checks.
 - c) Pressure-testing schedules.
 - d) Instrument loop test check sheets.
 - e) Installed instrument performance tests.
 - f) System tests.
 - g) Statutory certificates of compliance (such as hazardous area equipment).

Note: The Contractor shall submit and obtain approval of the FDS from the Employer Representative before beginning procurement. The contractor should take note of the importance of this obligation.

19.8 DESIGN REQUIREMENTS FOR INSTRUMENTATION, CONTROL AND AUTOMATION REQUIREMENTS

Minimum Design Consideration

The instrumentation, control & automation system shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than ten (10) years.

Instrumentation, Control, Automation system shall be designed, manufactured and installed to achieve the following basic requirements:

- to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- to suit the abilities of the staff who will:
 - use the systems;
 - service the systems;
- to measure, indicate, process, store and control the relevant parameters, as specified;
- to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of 'operations and maintenance' personnel and plant and to store and collate the data, as required;
- to derive, present and utilize, as required, such additional data as required to facilitate:
 - the most efficient operation of the plant;
 - the routine maintenance of the plant

Equipment and system shall be designed and constructed to perform accurately and safely under the environmental and operating conditions described or implied in this specification without undue heating, vibration, wear, corrosion.

Equipment and systems shall be supplied as per the vendor list indicated in specification elsewhere.

The equipment, systems and accessories furnished shall be designed and constructed to meet the performance specification during the continuous service life of the plant.

Contractor shall indicate the year in which the offered models of the instruments and control system have been introduced and how long the commercial production of the same is expected to continue. In any case, Contractor shall ensure supply of spare parts for minimum period of ten years. In case if it is felt by Contractor that certain equipment/component is likely to become obsolete, Contractor shall clearly bring it to the notice of

Employer and indicate step proposed to deal with such obsolescence like maintaining "bonded spares" with the manufacturer/s.

Any part/ module of the C&I system which are not listed under recommended spares shall be deemed as having life expectancy not less than ten years.

Contractor shall supply proven latest version of hardware and software available at the time of system designing. In case of future up-gradation of software, Contractor shall remain committed to upgrade the supplied system at per with the new version within the warranty period and O&M period and ensure successful integration of the system.

For the sake of completeness of the system and in order to ensure desired performance & safety measures, any hardware or software item felt required, shall be in the scope of Contractor irrespective of their explicit or implicit inclusion in the accompanying document.

Technical details furnished in the accompanying documents are subject to change in future within reasonable limits, which Contractor shall abide by.

19.8.1 Site Conditions

a. A. Temperature and Humidity Range

b. The equipment shall be installed in an environment having a temperature range of 0 °C to 55 °C and a maximum relative humidity of 100 % (non condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.

c. B. EMI/RFI Noise Immunity

d. The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.

e. C. Generated Interference

f. The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1 or equivalent Indian Standard for noise emissions.

g. D. Coordination

h. The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are specific regarding

dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.

i. E. Sequencing

- j. The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

19.8.2 Enclosure/Panel Details

(i) ENCLOSURES AND MOUNTING BOARDS

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment.

All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

Enclosures mounted inside buildings shall have a minimum rating of protection to IP 54.

Enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to IP 65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and direct sunlight. Also, when enclosures for use outside buildings are located where exposure to direct sunlight will give rise to high top-panel surface temperatures such that the internal temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure. The sun shield shall prevent direct sunlight from reaching the instrumentation for the full day throughout the year, and shall have louvered ventilation.

Note: Each field instrumentation shall be installed in an enclosure with minimum IP-65 rating. Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles.

Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

(ii) PANEL DESIGN AND CONSTRUCTION

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

Unless otherwise specified, panels shall be minimum 800 mm in width. The design and dimensions of control consoles and desks shall be determined according to their intended function and shall be in accordance with the requirements of the Specification. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level.

All panels (major/minor) installed outside shall be provided with lightning arrestors.

Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance.

Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

(iii) PANELS - MAJOR

Panels shall be constructed generally as specified in the preceding clause. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance.

Flanged edges shall be straight and smooth.

Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of center of gravity and method of fabrication, with the following minimum thickness:

- instrument bearing surfaces, gland plates and pneumatic distribution plates, 3mm;
- internal mounting plates, 3mm;
- doors, covers and filler panels, 3mm.

No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

Each panel shall be mounted on a self-draining base frame fabricated from 150mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel.

A chequer-plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable.

Sufficient removable un-drilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface mounted enclosure may form a part of the base or top.

Panels containing instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres on both side of the panel ,and top and bottom, to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces. If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections. All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection. Provision shall be made for safe and easy handling during transit and installation. If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cut-outs with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.

Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

(iv) PANELS - MINOR

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be classed as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause.

Panels shall be fabricated from sheet steel or other approved material less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface-mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed, issued to the Purchaser and subsequently replaced with bolts after installation.

Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

(v) PANELS - COMPOSITE

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and, at the sole discretion of the Engineer, ICA equipment may be combined within a single enclosure subject to the following conditions:

- The observance of all other clauses herein relating to enclosures, mounting boards and minor panels;
- The written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component;
- The total segregation of ICA equipment and switchgear including the glanding and termination facilities;
- The absence of any voltage exceeding 250vac or 50vdc from any compartment containing ICA equipment;
- The use of the full height of the panel (excluding the bus bar chamber and Cable space) for any ICA equipment compartment.

(vi) PANEL PROTECTION

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic molded insulating

material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage.

Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.

At least 25%, and not less than five, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainders are unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level.

(vii) PANEL ISOLATION

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the 'off' position. The 'on' and 'off' positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position.

Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the 'off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labeled with suitable warning notices.

Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the 'free' plug and a socket mounted adjacent to the device.

The power supply connector shall be a socket.

(viii) PANEL TERMINAL BLOCKS

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analysers, resistance thermometers, retransmitting slide-wires and thermocouples may be terminated at their appropriate instruments.

A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty.

Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal moldings shall be in melamine to BS 1322, polyamide or equivalent. Terminal rails shall be hot-dip galvanised. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Klippon type SAKC or equivalent which permit the connection of a test milliammeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or two internal wires shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit.

Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalized where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimize the risk of accidental contact.

(ix) PANEL INTERNAL WIRING

Panel circuits shall be segregated into the following categories:

Group 1: Power control and very-high-level signal wiring (above 50V):

- 1.1 ac power supplies;
- 1.2 dc power supplies;
- 1.3 ac current signals above 50mA (such as CT circuits);
- 1.4 ac voltage and control signals above 50V (such as PT circuits).

Group 2: High-level signal wiring (6V to 50Vdc):

- 2.1 signals from conventional electronic transmitters and controllers (such as digital or 4mA to 20mA);
- 2.2 circuits to alarm annunciations and other solid-state devices
- 2.3 digital signals;
- 2.4 emergency shut-down and tripping circuits;
- 2.5 on/off control circuits;
- 2.6 intrinsically safe circuits;

Group 3: Low-level signal wiring (5V dc and below):

- 3.1 signals from thermocouples;
- 3.2 signals from resistance thermometers and re-transmitting slide-wires;
- 3.3 signals from analytical equipment and strain gauges.

For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

- (a) The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel;
- (b) The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm² minimum copper conductor with HPDE or PVC-insulated cable of adequate grade and rating.

Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.5mm² minimum copper conductors with 250V grade, PVC-insulated cable of adequate grade and rating.

Wiring sheath colors shall be black for ac circuits, and grey for dc circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals.

All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than 75% of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded.

Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

(x) PANEL WIRING IDENTIFICATION AND TERMINATION

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a color coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally.

The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling.

Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

(xi) PANEL EARTHING

A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals. In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

SPD's associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three metres of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

(xii) PANEL VENTILATION

Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to

the environment in which the panel will be mounted. Fans shall be controlled by a suitably-labelled enclosed switch mounted internally in an accessible position.

Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

(xiii) PANEL LABELS

All control gear shall be fully labelled with the KKS code identifying the equipment designation/function, all external and internal components, all rating data, detailed equipment operating data and for danger and hazard warning.

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as detailed in the Specification. Wording shall be clear, concise and unambiguous and shall be subject to review by the Engineer before manufacture. Each label shall be permanently secured to the surface near the item to which it refers. Externally-fitted labels shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black.

The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally fitted labels, which shall be white with engraved black letters.

Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- To describe or identify circuits or circuit components;
- To identify dc polarity;
- To warn or remind about dangerous or potentially-dangerous circumstances;
- Wherever elsewhere specified.

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high.

The minimum practicable number of different sizes shall be used.

Manufacturers' nameplates shall not be fitted on panel external surfaces.

(xiv) PANEL FINISH

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Engineer. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer.

The overall dry film thickness (DFT) shall be between 85 and 120 microns.

Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanized or otherwise finished to an approved standard.

19.8.3 Instruments and ancillaries

n) General

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

All equipment shall be fully tropicalised and suitable for the worst environmental operating conditions. Panel-mounted instruments shall be of the electrically operated flush mounted type and shall have damp-proof and dust-proof cases.

Instruments mounted outside instrument panels shall have weatherproof and dustproof cases. Instrument cases shall be of corrosion-resistant material or finish.

Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust. Where applicable instruments shall be easily withdrawable from its housing for maintenance without interrupting its signal.

Unless otherwise specified, instruments shall be finished in the manufacturer's standard color. Instrument dials shall be of such material that no peeling or discoloration will take place with age under tropical conditions.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 150mm except where forming part of standard instruments and accessories such as air-sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal-transmission systems shall be in accordance with BS 5863: Part 1 or equivalent and shall use a signal of digital or 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the appropriate part of BS EN 60770-1 or equivalent. For the important and critical processes the transmitting devices, such as pressure, temperature and level gauges, shall have a reference gauge installed locally for easy reference for the operation and maintenance staff. The transmitters shall be provided with LCD meters.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the

manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory configured ranges, measuring instruments shall have zero and span adjustment.

Field mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

In order that maintenance and inspection may be carried out safely and conveniently instruments mounted in elevated and open work areas shall be provided with safety ladders and a sufficiently sized working platform with sun shading.

Indicating Instruments and Meters

All instruments and meters shall be flush mounted and generally of the same pattern and appearance throughout and those which perform similar duties shall be of uniform type and manufacture.

Indicating instruments shall be fitted with an externally accessible zero adjuster. They shall have no parallax error and their normal maximum reading shall be approximately 60% full scale deflection.

Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The ammeter shall have an adjustable and sealable red pointer set to indicate normal full load current. The ammeter physical size shall be in keeping with the size of the starter concerned. The minimum size to be used is 0.25 DIN.

Indicating instruments shall comply with IS 1248, BS 89 or IEC 60051 and shall be of industrial grade accuracy.

Kilowatt-hour meters shall comply fully with IS 722 or BS 5685 Class 2 and shall have industrial grade accuracy ($\pm 2.5\%$). Three element units shall be used for 3 phase 4-wire systems. Two element units shall be used for 3 phase, 3-wire systems.

o) Indicator Lights

Indicator lights shall be not less than 20 mm diameter and shall be panel mounted types with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lampholder or panel wiring. Lampholders shall be keyed into panels to prevent rotation. Lens colours shall comply with BS EN 60037 as follows:

power on		white*
running	-	green
tripped/alarm		red

status (open, closed, etc)	blue
ready to start	blue
warning (no imminent danger)	amber

Note: *white may be used where doubt exists as to which other colour to use.

The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% normal value or by using higher voltage lamps.

The indicating lamps on control panel shall be cluster of LED's.

p) Push buttons

Colours of pushbuttons shall generally comply with IS 6875, BSEN 60947, 60037 or IEC 60073 and in particular shall be as follows:

Stop, emergency stop	red
Start	green
jogging/inching	black
reset (when not also acting as a stop)	blue
lamp test	blue
override/alarm accept	yellow

19.8.4 Cabling

q) Instrumentation cabling

Instrumentation cables shall be of armoured screened type. Cables from conventional measuring transmitters and analogue process controllers, such as digital or 4mA to 20mA dc output from a constant-current source, (hereinafter referred to as high-level signals) shall be polyethylene or PVC insulated with stranded conductors and laid up as twisted pairs with one twist per 30mm approx. Each cable shall have an overall screen of braided copper or Mylar backed aluminum foil giving a minimum coverage of 85%, a steel wire armoring insulated from the screen and from any ducting and an overall PVC sheath. For runs exceeding 30 meters or for all inputs to a data logger, computer or microprocessor, multi-core cables shall have an individual screen of braided copper or Mylar-backed aluminum foil for each signal pair. The minimum conductor size shall be 24/0.2mm but shall be of greater cross-sectional area if required for the satisfactory operation of associated plant. Cables for intrinsically safe systems shall comply with BS 5308 and the relevant certificate.

Cables from strain gauges, analyzers and the like, such as 0 to 100mV (hereinafter referred to as low-level signals — see also below) shall be as specified above and shall have an individual screen for each signal pair.

Cables from indicating devices to alarm or tripping circuits shall be as specified above for high-level signals but shall use cables, cable trays, ducts and conduit separate from those for other high-level circuits.

Cables for high-level signals, low-level signals, resistance thermometers and thermocouples shall be segregated from each other and each shall be separated from cables for power, communications and other electrical services. Other cables run in the vicinity of instrumentation cables shall be twisted at the rate of one twist per 50mm approximately and shall be separated from instrumentation cables by a distance of not less than 300mm.

Initiating devices for plant protection and personnel safety shall be connected by individual cables direct to the tripping or safety device and shall not be routed via any intermediate junction, marshalling box, cabinet, relay or similar. The outer sheaths of such cables shall be coloured orange.

r) Telemetry cabling

Telemetry cabling between a master station and an outstation, unless otherwise specified, shall consist of a minimum of 6 signal pairs, of which two pairs shall be allocated to the telemetry system, one pair shall be allocated to a speech circuit and three pairs shall be spare. Each conductor shall be multi-stranded with an equivalent diameter of not less than 0.9mm. Conductors shall be laid up in starquad formation. The dc resistance of any pair of conductors shall not exceed 55 ohms per loop Km at 10°C and the difference between the resistances of the conductors of any pair shall not exceed 0.5% of the loop resistance of that pair. Telemetry cables shall be designed for burying in water-logged ground.

Conductors shall be plain annealed copper with aluminium/polythene laminate sheath moisture barrier, copper or brass tape pest barrier, single galvanised steel wire armour and overall polythene sheath. The cable shall have a solid filling of petroleum jelly.

The characteristic impedance of each signal circuit shall have a nominal value of 600 ohms at 800Hz and the circuits shall be suitable for signal input levels of between -30dbm to +4dbm (0dbm = 1mW into a load of 600 ohms). The overall attenuation between the terminations of any circuit at the mean frequency of the band width specified elsewhere shall not exceed 20dbm and the attenuation at any two frequencies within this band width shall not differ by more than 6dbm. The transmission time for any two frequencies within the band width specified elsewhere shall not differ by more than 1 / (4 % B) seconds, where B is the transmission speed in bauds, as specified elsewhere.

The signal-to-noise ratio within the bandwidth specified elsewhere shall be better than 12db. The frequency of any received signal shall not differ from the frequency of the corresponding transmitted frequency by more than 1% of the transmission speed in bauds specified elsewhere.

Loading coils as necessary to meet the performance requirements detailed herein shall be supplied and installed at equally-spaced points.

s) Fiber optic cable

To facilitate the proper and efficient co-ordination of the Works the Contractor shall sublet all Cabling Works to one Sub-Contractor who has proven and successful experience in fiber optic cable installations on projects similar to the one now proposed.

If cable sizes are not indicated on Drawings or in schedules, determine the correct size based on total end to end signal attenuation not to exceed 40 dB, including all splices and termination losses, and after taking into consideration.

- a) Type of fiber
- b) Ambient conditions
- c) Method of installation
- d) The disposition of each cable relative to others

All cables and wires shall be suitable for installation and continuous services in the ambient conditions described elsewhere in this document.

Shop Drawings and Product Data shall be submitted for the approval of the Engineers as follows;

- Submit full technical details of each type of cable proposed.

- Submit copy of test certificates from the manufacturer or an independent testing authority confirming that cables comply with the specification.
- Submit exact route of the cable run and relevant Sections in the shop drawings.

Each drum length of cable shall be allotted a distinct and separate reference number. This number shall appear on the test certificate covering the respective length of cable and shall also be clearly marked on the cable drum.

The Contractor shall advise the Engineer upon delivery to site of each drum length, quoting the reference number, the test certificates shall be handed to the Engineer for examination and approval.

All cables shall be delivered to site with the manufacturer seals, labels or other proof of origin intact. These labels and seals shall not be removed until the cable is required for use and shall be retained for inspection by the Engineer.

The Contractor shall be responsible for the off-loading and handling of the cables on site, and shall ensure that cables are delivered to site on drums and properly protected against mechanical damages. Where lengths are cut from cables, the open ends shall be sealed.

The contractor shall be aware of the need to supply and install all cables for this Contract which are most suitable for the special environmental conditions prevailing in this project.

The cable shall comprise 8 fibers, loose tube, two fibers per tube with central 1.5 mm nominal steel central strength member, moisture barrier, steel tape armored in continuous lengths up to a maximum of 6.0 km or as dictated by cable joint chamber locations and route survey.

Single Mode	
Type of fiber	Single mode, doped silica
Core Diameter	9.0 ± 0.5 micro m
Cladding Dia	125 ± 2.0 micro m
Coating (outer) Diameter	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.11 micro m
Attenuation	<0.4 dB/km @ 1300 nm <0.2 dB/km @ 1500 nm
Bandwidth	1000 MHz @ 1300 nm
Chromatic Dispersion	3.5 ps/nm x km @ 1300 nm 20 ps/nm x km @ 1500 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)
Multi mode	
Type of fiber	Multi mode, doped silica
Core Diameter	62.5 ± 3.0 micro m
Cladding Diameter	125 ± 2.0 micro m
Coating (outer) Dia	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.275 ± 0.15 micro m
Attenuation	<3.2 dB/km @ 1300 nm <0.9 dB/km @ 1500 nm
Bandwidth	500 Mhz x km @ 1300 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)

t) Cable termination boxes

Cable termination boxes shall have double-ended screw terminals with removable links to facilitate core isolation during testing. Each box shall contain sufficient terminals for every conductor plus 20% spare terminals. Cable termination boxes shall have cable sealing chambers and insulated glands with earthing terminals so that the armouring may be earthed or isolated from earth, as circumstances dictate.

Termination boxes for use within buildings shall be of sheet steel with hinged or removable front covers. All other termination boxes shall be cast steel or heavy gauge sheet steel construction giving protection to IP55. All termination boxes shall be hot-dip galvanised or approved equivalent finish. Each terminal box shall have a removable, un-drilled gland plate and the Contractor shall supply and fit the requisite number of cable glands.

At each cable termination box, each cable core (including spares) shall be identified by a numbered slip-over type collect. The numbering for a particular cable core shall be the same throughout its length.

Cable joints shall be at points approved by the Engineer.

Each cable joint shall be of the straight-through type. The conductors shall be ferrule-jointed with the insulation maintained by heat-shrink sleeving. Joint closure shall be made with epoxy resin and the completed joint shall be impervious to water if submerged or in waterlogged ground. If cast iron joint boxes be used, they shall be provided with cable glands and, after installation and testing, shall be covered with Densomatic HD compound or equal; so that all sharp corners, bolts and projections are moulded to a smooth surface. Two lappings of Densopol grade ZN 50mm tape, or equal, shall then be applied overall. Jointing shall be carried out on each conductor, including any provided in excess of the minimum quantity specified. All materials and things of every kind required for the cabling jointing shall be provided by the Contractor.

u) Junction Boxes

In order to make the most economic use of cable ladder/tray and duct capacity, multicore cabling shall be utilised in order to connect instrumentation groups by using suitably located sub-distribution junction boxes. The junction boxes shall have weather protection suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labelled. Junction boxes shall be constructed of die cast aluminium and with IP65 degree of protection.

Separate cables shall be used for digital and analog signals.

Wires and terminals for the digital and analog signals shall be segregated within junction boxes.

All Cable entries shall be from bottom side only in all Junction Boxes.

v) Cable labeling

At each end of each cable, in a uniform and visible position, a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels shall be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corrodible binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

Three-phase power cable cores shall be identified A, B, C or colour-coded red, yellow, blue so that the correct three-phase sequence is preserved throughout the system. Single-phase power cable cores shall be colour-coded red and black.

Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of colour-coded ferrule markers. The size of these ferrule markers shall be such as to match the overall diameter of conductor plus insulation. Numbering shall read from the termination upwards on all cores.

Each cable and core shall bear the same number at both ends of the cable and core respectively.

- (a) Power terminations — colour, number or letter.
- (b) Control terminations — letter or number or both.

w) Cable terminations

All PVCSWAPVC, PVCPVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide adequate mechanical support. Each cable gland shall be protected by corrosion-resistant molded PVC hoods, covering the entire assembly from the overall sheath to the gland neck.

Glands for armoured cables shall provide a positive armour clamp to the enclosure so that no tension is applied to the termination. The clamp shall also provide a high level of earth continuity and be of adequate size to withstand the full fault current of the system for one second.

All glands shall be provided with an earthing tag. For cables of 4mm² or less, a serrated washer may be used instead for earth continuity.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

Through joints shall be permitted only on long cable runs outside buildings. Where such joints are necessary; the cables shall be jointed with epoxy or acrylic resin Cold-setting compound which has been pre-measured and pre-packed ready for use.

The boxes shall be of a split moulded plastic type with filling vents for compound.

Bonding straps shall be fitted with armour clamps across the joint and inspected by the Engineer prior to filling the box with compound. Wrapped pressure type joints shall not be accepted.

Conductor cores shall be jointed number to number or color to color.

x) Cable installation - General

Cables which are to be run on walls, ceilings or other building structures shall, unless otherwise agreed by the Engineer, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Cables shall not be installed in areas of direct sunlight.

Where this is unavoidable, approved sun shields shall be supplied and installed.

Where the building structure incorporates purpose-built covered duct or trench systems for main cables, instrumentation cables shall be segregated and installed on tray work or otherwise secured to the sides of the duct or trench.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the walls unless otherwise agreed by the Engineer.

Cables shall be spaced to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings, such as rawl plugs.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand Site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used. The arrangement and fixing of each cable shall permit the removal and replacement of any cable without disturbance to any other cable or the fixings thereof.

When cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

Submissions which the Contractor shall submit the following in relation to cable installations in addition to submissions detailed elsewhere in the Specification.

y) Drawings and schedules

- Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.
- Cable route and layout drawings. For those items which are underground, these drawings shall include the following:
 - Route plans and sectional views for all cable runs, cable trays, cable ducts and cable trenches;
 - The position of all marker posts, joints, draw pits and the like.
 - Cable schedules shall detail the cable number, type, voltage, size, route length and number of cores or pairs. Control-cable schedules shall detail the connected and spare core numbers, diagram number for connected equipment, core ferrule and terminal reference number.

z) Data and calculations

- Manufacturers' catalogues and data sheets for all cables and fittings. Cable sizing calculations.

Test certificates

- Test certificates for all witnessed and routine tests carried out at the manufacturer's works and at Site.

aa) Cable trays and ladders

Cable tray and cable-support ladders shall be of heavy-gauge galvanised steel and with an overall PVC coating when required to the approval of the Engineer.

Cable tray and ladder systems shall be installed using factory-made supports, joints and junction/bend pieces. Wherever tray and ladder sections are cut and shaped on Site, cut edges shall be dressed and painted with at least two coats of cold galvanising compound or lead-based anti-corrosive paint.

Ladder systems shall be secured to walls and ceilings by pre-formed galvanized interlocking channel.

bb) Flexible conduits

Flexible conduit shall be of the waterproof galvanised type of PVC wire-wound type with cadmium-plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough-type box. The flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws and the like will not be permitted. Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

cc) PVC conduit

Where galvanised conduit would be liable to corrosion, PVC conduit shall be installed.

PVC conduit shall be of the oval or round high impact non-flame-propagating type as specified and self-extinguishing, to BS EN 61386-21. Surface and concealed installations shall be generally as described for steel conduit.

PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

Jointing shall be carried out using PVC solvent and socketed accessories.

Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose-made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures of between -5°C and +60°C and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth-continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat-resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes, the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaires or other heat sources shall have either external fixing lugs riveted to the metal inserts or utilize steel insert clips.

19.8.5 Cable Installation methods

dd) General

All cabling installation methods shall be subject to the approval of the Engineer.

Installation directly into the ground

Where cables are buried in the earth, the bottom of the excavated trenches shall be freed of sharp stones and other projections and covered with sand to a depth of 50mm.

Cables shall be unrolled from drums without loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp projections.

Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100mm of compacted sand and shall have a layer of protective interlocking concrete cable tiles. The tiles shall be overlaid with marker tape.

When cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.

ICA and communication cables shall be laid not closer than 1000mm to high voltage cables. A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

ee) Installation in underground ducts

Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 500mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100mm shall be laid at a minimum depth of 1000mm (to the duct centre). The ducts shall be encased by 150mm concrete on all sides.

When installing cables in ducts, the following measures shall be observed:

- Cables shall be pulled in a straight line;
- Rollers shall be positioned at the edges of drawpits both at the drawing-in and drawing-out points over which the cables shall be drawn;
- uPVC pipes and cable sheaths shall be coated with an approved lubricant;
- Sufficient draw-in points shall be provided and adequate room allowed for installation of cables;
- The pulling rope shall be guided by rollers.

Only one power cable shall be drawn into each duct.

Whenever a duct is laid in the ground, a draw-wire shall be pulled through with at least 1000mm excess at each end and the draw-wire left in position if the duct is not to be used immediately.

ff) Sealing cable entries into buildings

Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with silicone foam or similar.

All cable entries into a building shall be in ducts and where the cables pass in or out of ducts, together with any spare ducts, the ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes.

gg) Marking of underground cables

The location of all underground cables shall be identified by:

- Brass plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall;
- Marker posts in road verges and the like at intervals of not more than 100m and at all junctions and changes of direction along the route;
- Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 200mm high above ground with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of a cable below, the depth, classification and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer.

hh) Installation in cable trunking

Cable trunking shall be manufactured from mild steel of not less than 1.25mm and shall be hot-dip galvanised. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity. Trunking shall have minimum dimensions of 50mm x 50mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick-fix type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose-made by the manufacturer and of a matching design to the main trunking.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes. Trunking shall be supported at intervals not greater than 2m horizontally or 2.5m vertically. Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking, the bared ends shall immediately be given a coat of zinc-rich cold galvanising paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Engineer before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services. Trunking systems erected outside a building shall be weatherproof.

ii) Installation in troughs and trenches

Where the building structure incorporates purpose-built covered trench systems, power distribution cables may be laid on the floor of the trench. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.

Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls. Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipework.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1mm for trays up to 100mm width, not less than 1.25mm for trays from 100mm to 150mm width and not less than 1.5mm thickness for trays from 150mm to 300mm width.

Cable-tray supports shall be of sufficient strength to maintain rigid support to the fully-laden cable tray along its entire length. All brackets and tray work shall be suitable for withstanding a temporary weight of 125kg.

Wherever possible, cable trays shall be installed in full lengths without cutting.

Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc-rich cold galvanising paint. Similarly for PVC-coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose-made saddles, as approved by the Engineer, together with proprietary cable cleats.

jj) Installation in buildings

Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or simply at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.

Cables shall be located between 50mm pegs spaced at 40mm centres across a rung so that a 40mm or 80mm space is maintained between cable centres. Cleats shall be used where the ladder racking is vertical.

Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipework.

Cable installation in conduits

Conduits shall be either galvanised heavy-gauge steel screwed type or light-gauge steel non-screwed type, steel or PVC. Accessories shall either be malleable cast iron or pressed steel.

A space factor of 40% shall not be exceeded and, in any case, conduit shall have a minimum diameter of 20mm. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed and all sharp edges removed before erection.

Where conduits converge, adaptor boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25mm diameter, straight-through joint boxes shall be of the trough type. Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All function boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

19.8.6 Field Instrumentation

kk) General

- Instrumentation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.
- All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalised. The outdoor equipment shall be designed to withstand tropical rain. Wherever necessary space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.
- All instruments shall be from the country of origin as indicated in the preferred vendor list elsewhere in this specification.
- All instruments shall be offered for inspection & testing before dispatch, at Manufacturers Factory works where the instrument has been manufactured. The

same shall be indicated in the QAP and submitted along with the equipment datasheet for review and approval.

- Electronic instruments shall utilise solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.
- No custom made hybrid type integrated circuits shall be used.
- Unless otherwise stated, overall accuracy of all measurement systems shall be $\pm 0.5\%$ of measured value, and repeatability shall be $\pm 0.5\%$.
- Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.
- On resumption of the supply following a power failure the instruments and associated equipment shall start working automatically.
- The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.
- Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65.
- All outdoor instruments shall be fitted with IP65 enclosure to shield the instruments against the weather, irrespective of the IP rating of the instrument/transmitter. The enclosures shall be of lockable type.
- The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail but in any case not less stringent than those conditions detailed in the Project Requirements. Instruments shall be resistant to corrosion in the atmosphere in which they are expected to operate.
- All field instruments, and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Employer for approval before any labels are manufactured.
- All coated parts of sensors shall be made out of noncorrosive material .
- For all instruments installed in the field, surge protection devices (SPD s) shall be provided at both ends of the connecting cable for protection against static discharges / lightning and electromagnetic interference.
- Individual pair screened, overall screened, armoured cables shall be used for analogue signals and armoured, overall screened cable shall be used for digital signal cables.

II) Level Measuring System

(i) ULTRASONIC LEVEL METERS

Ultrasonic level measuring devices applied for liquid level measurement shall comprise a transducer, control unit and remote indicator.

The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected to IP 67. It shall have ambient temperature compensation, adjustable datum setting facilities.

The accuracy of the sensor shall be $\pm 0.25\%$ or better.

It shall be programmable with an integral programming keyboard and provide a digital display of the measured variable. It shall be provided with diagnosis facilities and shall provide an isolated 4 to 20 mA dc output signal proportional to the range of measurement.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

Shielding, stilling tubes or other measures as required shall be provided to avoid effects on the measurement, with the approval of the engineer.

(ii) CONDUCTIVITY LEVEL SWITCHES

The electrodes used for conductivity level switches shall be stainless steel. Single electrode systems (one electrode per holder) shall be used (except where their use is impractical) with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level.

Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall be fitted with conductivity discs.

Where relay or control units are not mounted in control panels, they shall be provided with surface mounting enclosures with a degree of protection to IP 55 for indoor locations or IP 65 for outdoor locations.

(iii) FLOAT-OPERATED LEVEL METERS

Float-operated level meters shall comprise a float and counterweight or tension device. Floats and counterweights shall be of corrosion-resistant material or shall be coated with epoxy resin. The float shall be suspended by a stainless steel wire or perforated tape which shall operate the transmitter installed above the float stilling well or measuring chamber.

The transmitter shall provide a digital or 4mA to 20mA dc output signal proportional to the level range of the instrument and shall be provided in an enclosure with protection to BS 5990, IP 55 or equivalent standard.

mm) Surge Protection Devices

Surge protection devices (SPD s) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protect the instrument to which it is connected against damage. SPD s shall provide protection through the use

of quick acting semiconductors like Tranzorb, zener diodes, varistors and an automatic disconnect and reset circuit. SPD's shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self-resetting to minimise the down time of the measurement loop.

SPD's shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located out of doors.

The surge protection device shall be rated for surge rating of 10 KA.

nn) Alarm Systems/Alarm Announciators

Alarms shall be initiated by the opening or 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.

Audible devices in the same room or area shall have distinguishable sounds and adjustable sound levels.

(i) MATRIX TYPE ALARM ANNUNCIATORS

Each alarm shall initiate a visible and audible indication of the specified condition. Unless otherwise specified, alarm indicators shall be grouped together in annunciator units each having at least 20% spare ways. Alarm indicators shall be of similar design to indicator lamps and shall have screens engraved with legends approved by the Engineer. The legend area of each indication shall not exceed 40 mm high and 75 mm wide.

When any alarm condition occurs, an audible device common to an alarm annunciator system shall sound and the appropriate indicator shall flash on and off. The flashing rate shall not be less than 2 Hz and shall not exceed 5 Hz. On pressing an accept pushbutton, the audible device shall be silenced and the flashing light shall become steady. The alarm indicator shall remain illuminated until the alarm condition ceases and a reset pushbutton has been operated.

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 further alarm condition occurs. At unmanned locations alarms operated on two or more annunciators shall require acceptance at each annunciator. Alarms shall be accepted automatically and the appropriate audible device silenced after an adjustable period of 1 to 5 minutes.

An integral 'test' pushbutton shall be provided to illuminate each lamp in the appropriate group and to operate the audible device but shall not cause a spurious alarm condition on any other annunciator. Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds do not initiate any action.

All push button shall have not less than one million mechanical operational life cycle on a minimum. The same shall be indicated in the datasheet and test certificate by the OEM shall be submitted for review and approval in the QAP.

Alarm annunciator / indicator legends or labels shall be arranged with three lines of text as follows:

Top line	Location
Middle line	Parameter
Bottom line	Status
e.g.	Pump-TRIP
	Level High
	Tide level High
	Gate—FAIL TO OPEN

19.8.7 Installation Requirements for Instruments

oo) General

The contractor is responsible for coordinating the installation, testing and commissioning to assure proper interface and system integration. Services shall include, but not necessarily be limited to all labour, materials, tools, equipment, supplies and services and auxiliary devices including brackets and mounting hardware required to install the instrumentation.

pp) The following general installation guidelines shall apply:

- Transmitters and transducers shall be mounted as near as practical to the measurement point.
- Instruments shall be always be readily and safely accessible from grade, permanent platforms or fixed ladders to facilitate ease of maintenance for the equipment.
- Supply power to instrumentation from the control panel to which information is reported for remote monitoring. Provide a separate (independent) circuit for each instrument (note that control panels are powered by online UPS and supplied from the sites critical emergency power circuit).
- Unless otherwise shown or specified, mount instruments 1.4 m above finished floors, grade or platforms. Allow for cabinet plinth/floor-pad heights when locating panel instruments.
- Do not mount direct reading or electrical transmitters on process piping. Mount on instrument racks or stands or in enclosures near the sensor at a level that permits viewing from ground elevation.
- Do not mount instruments on vibrating structures (e.g. handrails), or on piping or near equipment that may induce vibration.
- Do not mount instruments below or directly adjacent to lines conveying corrosive chemicals or near sources of leakage or spillage.
- Install the instrumentation and auxiliary devices (including sensors) such that they are accessible for maintenance. Provide space between instruments and other equipment and piping for ease of removal and servicing. Install to ensure accessibility from grade without requiring staff to enter confined spaces.
- Ensure that instrument displays are properly oriented for easy viewing.
- Any instrument that is not easily accessible for operation or maintenance, and any indicator that is not easily and readily visible, must be relocated as directed at no charge to the contract.
- Follow additional installation requirements as specified in the individual instrument sections and as recommended by the manufacturer.

- Follow the Manufacturer's recommendations for loading resistors on digital outputs to limit the affect of leakage currents through triac and relay outputs.
- Follow the Manufacturer's recommendations for surge suppression on inductive loads.
- Unless specifically instructed otherwise, ensure installations conform to the manufacturer's installation recommendations.

19.8.8 Control and Automation Requirements

The contractor shall provide a PLC based SCADA control and automation system to control and monitor the pumping station facility and the communication system to transmit the complete operational data to the pumping station control system. It shall be the contractor responsibility and minimum scope of work to include all required hardware and software to achieve the complete functionality as described in this document.

Minimum Scope of Work (Control & Automation)

- In particular, the following configuration shall be applicable across the pumping station's. Each Pumping station control and automation system shall be based on PLC based SCADA system. PLC system shall be a hot standby PLC linked to the plant redundant SCADA system. Additionally, systems shall be furnished with individual RIO panels (if required), with redundant RIO modules which shall communicate with the main pumping station PLC for monitoring and control.
- Each pumping station shall be equipped with a SCADA system which shall be dual redundant. The control system shall comprise of SCADA on dual servers and with 32" LED monitor systems. All the equipment shall be installed in a system console as per the vendor list as specified elsewhere in the document.
- Each pumping station shall be equipped with Color close circuit surveillance (IP based) systems (minimum 5 locations) with high speed internet bandwidth during the entire construction period for remote monitoring of the construction progress. After the completion of the construction and commissioning of the plant, the CCTV & high speed internet bandwidth systems shall be maintained till the end of the contract period inclusive of O&M period. The CCTV feed shall be interfaced to the 65" LED Screen (to be supplied and installed by the contractor) in the pumping station Control room. Additionally, the CCTV feeds shall be web based such that the CCTV feeds shall be monitored from a central location by the end user in real time.
- The pumping station control system shall be designed and implemented to transmit the complete operational data via redundant GPRS communication system (to be supplied by the contractor) under this contract to a remote central monitoring control system and vice versa (i.e receive the data, operational

commands (remote control & monitoring) from a remote central location control system).

- All required interoperability tests, required co-ordination, mapping of data, all required hardware & software, high speed internet bandwidth and leased lines ,compatibility of modems to achieve complete integration to share and accept remote operational commands, shall be considered as integral scope of work under this contract.

PLC System:

PLC shall comprise of necessary redundant processors, Simplex input/output (I/O) modules, redundant power supply modules, communication interface modules and 16" color touch screen Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs;

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications. PLCs shall be microprocessor based. PLCs shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

The complete PLC System & all RIO systems should be housed in air conditioned environment and the temperature in the control room shall be maintained at 23 degrees at all times. The contractor shall submit the sizing calculations for the air conditioning system for the control room considering all the equipment, heat generated ,etc for review and approval. The contractor shall refer the approved vendor list for the PLC system and hardware, elsewhere in this document.

The PLC based SCADA system (Inclusive of the redundant communication system, LED Screens, complete field instrumentation and CCTV system, control room lighting loads) shall be supplied with minimum 10 KVA un-interruptible power supply (UPS) with 60 mins backup on full load.

qq) Remote input/output modules (RIO)

The PLC system shall be connected with field remote input/output modules (RIO) panels.if required Each RIO panel shall consist of redundant communication modules,

redundant power supply modules, minimum 16" Color panel mounted HMI with touch screen functionality to enable control and monitoring with access logins. Each RIO It shall be possible to view and acknowledge the alarms and view set points for the particular & connecting processes from the HMI etc.

rr) Central Processing Units

The central processing units (CPU) shall be a high performance processor with modular configuration suitable for real time process applications

The following additional features shall be provided.

Communication between CPU and peripherals shall be by an I/O bus. The individual device, interfaces shall be capable of being plugged into the I/O bus. On resumption of power following a power failure the PLC shall automatically restart its controlling function. CPU shall have a real time clock capability to accept a time synchronisation pulse and adjust its internal clock with the pulse.

CPU shall have extensive self-diagnostic facilities and watch dog timers to identify faults at card levels

ss) Memory Unit

Memory unit shall comprise of highly reliable memory chips which are industry standard, proven design with fast random access and suitable for operation in process environments. Main memory shall be modular and facility shall be provided for the upgrading and expansion of memory to meet future demands.

Not less than 50 % spare program memory and data memory space shall be provided. System initialisation and application software shall be stored in EEPROM or EPROM. Operating data shall be stored in a RAM fitted with an internal battery back up. The battery back up provided shall support the memory on loss of power for at least one month. The battery life shall be at least 2 years. The contractor shall submit documentation to demonstrate the same.

tt) I/O Modules

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU. Refer the approved vendor list for the PLC system and hardware, elsewhere in this document.

Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable. Provision shall be provided for future expansion of additional 30% extra I/O modules of the installed capacity in the panel.

I/O modules shall be as follows:

- a) Inputs shall be opto isolated;
- b) filters shall be provided for noise rejection;
- c) output status shall be indicated by an LED;
- d) all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;

- e) All the modules shall be of addressable type.
- f) Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 Base T connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

19.8.9 Ethernet Switches

The contractor shall only provide managed industrial grade Ethernet switches under this contract at all locations (PLC, RIO, SCADA room).

19.8.10 UPS System:

The PLC based SCADA system (Inclusive of the communication system and FOC system, PCM system and complete field instrumentation shall be supplied with 10 KVA un-interruptible power supply (UPS) with 60 mins backup on full load.

19.8.11 PLC Programming

The Contractor shall supply, install, program and commission the PLC using the PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation. The contractor shall submit credentials of the software for review and approval before commencing any programming works.

PLC programming under this contract shall be implemented using functional block diagrams (FBD).

The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance.

The system shall support a simple programming of the application software comply with IEC 61131-3.

The system shall support a structured, modular programming. At least the following standard operations shall be applicable:

- 1) Logic functions (such as AND/OR/AND NOT etc.);
- 2) Timer functions (externally adjustable);
- 3) Counter functions;
- 4) Skip functions;
- 5) Comparison functions;
- 6) Limit value functions;
- 7) Arithmetic functions;
- 8) Physical unit functions;
- 9) Closed-loop functions such as P/PI/PID/etc.

The Contractor shall submit the logic diagrams for review & approval as an integral part of FDS submissions.

The Contractor shall provide all required IT Hardware complete with PLC coding and documentation software as specified in the bid document & as agreed with the Employer representative based on the FDS submitted.

19.9 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

The Pumping station shall be equipped with dual redundant SCADA system, which shall be suitable for day to day operation in the monitoring and operation of the pumping station works and other allied works as required under this contract.

SCADA Control Room:

SCADA shall be provided at central Monitoring Room which shall located to provide a complete uninterrupted view of the complete pumping station facility. The SCADA control room shall be sized to house the following equipment on a minimum but not limited to, and have the following features:

1. Redundant PLC system
2. Redundant SCADA servers and all related systems
3. Industrial system console
4. 65" LED Display screens and 32" LED monitors for each SCADA server
5. UPS system with 60 mins backup on full load (UPS batteries shall be housed in a separate room)
6. False flooring and false ceiling in the control room. Control room shall be provided with bio metric access to prevent un-authorised access to the control room.
7. Full length Glass walls to provide complete unhindered view of the pumping facilities
8. Air conditioning system

9. CCTV Surveillance systems

The Pumping Station shall be provided with a Dual redundant SCADA system. The SCADA software shall be of minimum 5000 tags version. The SCADA System and related computer hardware, shall be designed and sized to store, archive and retrieve complete plant operational data for at least twelve (12) months at any given time. The system shall be designed to retrieve the stored data and display the same in form of reports, trends, etc .This shall include on a minimum all alarms, levels, Pump Start/Stop data , Tide levels, etc.

On a minimum, the SCADA system shall generally consist of the following:

- 1) Redundant SCADA software of minimum 5000 tags
- 2) SCADA redundant servers
- 3) Each SCADA server station shall be with licensed software (Latest Windows OS, Anti-Virus software, firewall, required licensed software)
- 4) A 4size Alarm printer
- 5) A3 size All in One printers

- 6) Managed industrial grade Ethernet switches
- 7) 65" LED touch screen shall be provided which shall act as a mimic for the SCADA & CCTV system
- 8) Industrial grade control room console with minimum 5 nos of ergonomically designed seating systems for plant operators and supervisors.
- 9) File record shelves with glass doors with locking facility (at least two) to store SCADA alarms, records, operator notes,etc.,,,,

SCADA control room shall be equipped with False flooring & false ceiling. The entire control room shall be provided with air-conditioning systems (at least four nos of 2 tonne air conditioners in the main control room area). The brick masonry works in the control room shall be replaced with full length glazed windows .No UPS system shall be installed in the control room. A separate UPS room with battery room shall be provided in the administration building for the purpose. The SCADA control room shall be equipped with false flooring to provide access for all cables. No cables shall be installed over the control room floor.

The SCADA system shall provide efficient and safe operation of the pumping station by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimisation. The SCADA system shall allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities after successful log-on by security password.

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PARTICULAR REQUIREMENTS- INSTRUMENTATIONS, CONTROL & AUTOMATION

20.1 INTRODUCTION

This part covers the particular requirements for the design, supply, installation, inspection and testing of the Instrumentation, Control and Automation and associated plant and materials.

20.2 GENERAL

This section outlines the particular requirements for the instrumentation, control & automation works. This section shall be referred in conjunction to the general requirements for instrumentation, control and automation works specified in this document. Unless specified in this section to the contrary, the system provided by the Contractor and workmanship shall comply with the General Chapters of these Requirements.

The minimum scope of instrumentation, control and automation (ICA) works for pumping stations shall comprise the design, manufacture, programming and configuration, off site testing, delivery to site, installation and erection, testing, commissioning, setting to work and provision of documentation for a complete and reliable supervisory, instrumentation, control and automation system including the interfaces required to provide monitoring and control for a safe and efficient operation of the complete system.

The Contractor shall submit and obtain approval for all ICA equipment from the Employer's Representative before beginning the detailed control system design. Refer approved vendor list for instruments and automation.

At the time of bid submission, the contractor has to submit the completed technical schedule of the proposed instruments as per the technical schedule. All relevant manuals should be attached.

The control system shall be based on the use of programmable logic controllers (PLCs), which shall be configured with hot-standby CPU.

The PLCs and Input/output modules used for the Works shall be from the same manufacturer and series and shall as far as be practical allow for the interchange of plug in parts.

The PLCs and the central HMI shall be linked over dual line local area network (LAN) which shall be established on optic fiber cable with a single mode glass type.

A general arrangement of a typical control system is shown in the Drawings.

The control systems shall recover fully to a normal operational state on restoration of the power (either from the mains or the generator) after a power failure without manual intervention. (i. e. to remove doubt this requirement refers to a real failure of power to the control system such as would be experienced if the control system UPS s were not present).

The control system shall be designed with a combination of both manual and automatic mode of operation. In general, the complete pumping station shall be operated in complete Automatic mode of operation via the PLC based SCADA system. In all cases, facilities shall be provided to permit automatic controls to be overridden and the systems to be manually controlled. However contractor shall note that the complete plant shall be run in full automatic

load with all interlocks all the time. Only when the auto mode of control system is unavailable, then the plant shall be run in manual mode .On availability of auto mode, the plant shall be reverted back to auto mode of operation of the pumping station.

Local manual controls shall be located adjacent to Plant where required for day to day operation. All drives essential for the continuous operation of the plant shall be provided with a standby.

The process control system must be state-of-the-art in terms of structure and function as a process information and control system and its hardware and software must be future-oriented. The control system should be a modern system with an appealing user interface, open to the office and process world, with sophisticated and reliable functions, efficient to configure and scalable for simple and complex tasks.

The communication channels modules for the connection to the Programmable logical controllers via various communications media must be included in the scope of delivery of the control system, the same applies to drivers for simple types of coupling such as point-to-point via the MPI interface. In addition, it should be possible to establish the coupling to other devices and applications from various manufacturers via the standardized software interface OPC.

On a minimum, the SCADA hardware shall be based on the following:

- Main computer (SCADA server) Windows® 2019 Server (latest version)
 - Hardware and software from the PC sector can be directly used (e.g. LAN cards)
 - Can be used as single-user or multi-user system with client/server structure
- Scalable performance by selecting suitable hardware platforms .

Integral online parameterization option

A prerequisite is a comprehensive parameterization system that is integrated in the system, which allows the user to adapt the scope of functions and the functionality to any changed requirements without any programming expertise. The system must offer the option for carrying out these parameterization operations online. In practice, this means that the respective editor can run in a second window during operation and the configuration engineer can make changes to his application without exiting process mode and also without affecting the background activities. In addition, it should be possible to make configuration changes on the client as well .

20.3 HARDWARE

The control system hardware shall consist of field controls which comprises on a minimum but not limited to:

- PLC s;
- Redundant power supplies;
- Panel HMIs;
- Alarm annunciators
- field cabling interfaces.

- Redundant communication equipment
- Redundant SCADA server and auxiliaries;
- CCTV station;
- 65" inch touch screen video display
- Un-interruptible power supply.

The site instrumentation shall also form an integral part of the control system.

The equipment detailed in the aforementioned field controls list (with the possible exclusion of the power supply) and some components of the instrumentation system shall be housed within a number of control panels (CP s). Each panel shall be located adjacent.

The control panels shall provide separate areas for the PLC, internal power distribution, instrumentation, field cabling and for any surge (lightning) protection devices (SPD s). A separate instrumentation earth (a 'clean' earth) shall be established within the control panel. Instrumentation and control cable screens shall be connected to this earth.

The complete PLC based SCADA system inclusive of the RIO systems shall be housed in AC environment.

20.4 POWER SUPPLY

The Instrumentation and plant control system shall be powered from online 10 KVA uninterruptible power supplies (UPS). These shall be sized to provide sufficient power to maintain the Instrumentation and plant control system (inclusive of all field instrumentation, PLC based SCADA inclusive GPRS communication equipment, CCTV equipment and CCTV station with 32"LED screens, all vendor package instrumentation, control room lighting loads) systems functioning for a period of not less than 60 minutes on full load.

The status & online parameters of UPS shall be monitored from the SCADA system and an alarm raised via the control system if a fault occurs or the UPS battery supply is about to expire.

20.5 VOLTAGES

The following control voltages shall be used:

Item	Voltage
1. within starter enclosures	240 V AC
2. instrumentation power supplies	240 V AC / 24 V DC
3. PLC inputs cards	24 V DC
4. PLC outputs	24 V DC

20.6 CONTROL SYSTEM PROTECTION

1. Short Circuit

All circuits shall be protected against short circuit by the provision of adequate numbers of fuses or miniature circuit breakers.

For ease of maintenance and system security power supplies to each instrument loop and each PLC output shall be protected with an individual fuse (terminal type).

2. Surge Protection

Surge protection devices (SPDs) shall be provided at the control panel end of all instrumentation and control cables which run for distances in excess of 50 m outside the

confines of the building in which the CP is housed. The SPDs shall be grouped in a specific area within the CP to ensure 'dirty' signal cables do not come into direct contact with 'clean' signal cables.

20.7 DUTY / STANDBY DRIVES

The duty pump for each duty / standby pair shall be selected at the local control panel and the Plant HMI.

The control logic shall automatically start an 'available' standby in the event of the duty drive failing. The new duty drive shall take on the role of duty drive in all respects and shall continue to run as duty until manually reselected to standby or it fails.

20.8 INTERLOCKING

Hard wired interlocking shall be provided for safety circuits such as:

- motor protection;
- run dry protection;
- emergency stop circuitry;
- rotation monitor.

In addition drives stopped as a result of the action of hardwired interlocks shall in addition have a fault signal conveyed to the drive in order that the PLC drive run output is removed. Soft wired interlocking is provided by the PLC for process control and for safety trips when the signal is derived from a remote source (e.g. stopping of the pumps as a result of a high level in a downstream clear water reservoir).

20.9 ALARM ANNUNCIATION

Alarms shall be annunciated at three locations, at the drive starter, at the local RIO HMI and at the central SCADA. A philosophy shall be adopted that all alarms associated with a drive shall be annunciated at the starter whilst a general alarm only for that drive shall be enunciated at the HMIs. Therefore the operator observing a general alarm at an HMI shall have to go to the starter concerned to determine the exact cause of the alarm condition.

A typical alarm schedule is detailed in below table

Table : Alarm Schedule

Device	Alarm at the Starter/Panel	Alarm at the relevant local and central SCADA
1. Power System		<ul style="list-style-type: none">- transformer fault- mains incomer tripped- generator incomer tripped
2. Pump drives	<ul style="list-style-type: none">- overload (see note 1)- earth fault (see note 1)- emergency stop operated- run dry protection operated	<ul style="list-style-type: none">- drive fault (see note 2)- to be decided during detailed engineering
3. Valve actuators	<ul style="list-style-type: none">- drive fault	<ul style="list-style-type: none">- drive fault

		- to be decided during detailed engineering
4 level		- high high water level - high water level - low water level - low low water level
5 Pumping main pressure		- high pressure
6. Control system		- SCADA to PLC and PLC to PLC communication faults (various)
8. UPS s		- fault - battery low
9.Communication failure		-Communication failure between sites

Notes:

1. These alarms may be displayed on the motor starter panel. If this is flush mounted further individual indication may not be necessary.
2. These alarms are derived within the PLC from the analogue level value.
3. The Contractor shall provide all alarms necessary for the proper and efficient operation of the plant.
4. The above mentioned alarms are indicative only of the number and type of alarms that are required. The Contractor shall provide the above alarms on a minimum and other alarm necessary for the proper and efficient operation of the plant.

20.10 COMMUNICATION MONITORING

The control system shall continuously monitor LAN communications and raise an alarm at the central SCADA if communications should fail between the SCADA and a controlling PLC/RIO or between PLCs if inter-PLC communication is being used. A separate SCADA screen (mimic) showing the real time status of PLC's, I/O modules, LAN communication ,RIO status, etc. is to be incorporated.

20.11 INTEGRATION REQUIRED UNDER THIS CONTRACT WITH OTHER CONTRACTS & COMMUNICATION METHODOLOGY TO BE ADOPTED UNDER THIS CONTRACT

a) Scope of Work for Integration & communication between sites:

- 1) Data from the pumping station is required to be transmitted to the remote central monitoring station for use in its control and monitoring, and also receive the data communicated from the remote central monitoring station for complete monitoring and control as required.
- 2) The Contractor shall provide all facilities to output from the control system via redundant GPRS communication system, the discrete signals to be sent and to accept the discrete signals provided.
- 3) The Contractor shall provide termination details to permit these connections to be carried out. The Contractor shall co-ordinate in full with other Contractors of other packages to interface with pumping station control system.

- 4) **Interoperability Test & Integration co-ordination:** The contractor shall conduct a interoperability test to confirm & demonstrate that the local control system data can be read & written by the remote centralized control center using appropriate OPC server & client software .The contractor shall submit Interoperability test document for each site for review and approval. The same shall be demonstrated during control system FAT. Final interoperability test shall be carried out in presence & co-ordination with the contractor of respective packages as indicated in this clause.
- 5) It is required that the contractor maps his I/O's for integration in the format as required to complete achieve complete integration and to communicate and receive data as required. The contractor shall transmit complete plant data as a minimum requirement under this contract.
- 6) The contractor shall co-ordinate fully with the respective contractor for integration tests.
- 7) **Communication Methodology between sites/locations /contracts to be adopted under this contract:** The contractor shall note that GPRS communication system shall function as the primary mode of communication. The SCADA & communication interface shall be so designed to switch between the redundant GPRS mode of communication automatically on pre-defined intervals in order to cross verify the readiness and working of the communication system at all times. The frequency of switchover shall be minimum 2-3 times in a week .The switchover philosophy shall be detailed in the FDS .This shall be in co-ordination with control system of remote centralized monitoring system. Co-ordination and interoperability testing between remote centralized monitoring system shall be under the scope of the contractor. Contractor to note the importance of this clause.

b) Minimum Data to be provided by the PS Control System but not limited to:

The contractor shall provide complete SCADA screen dumps with all data, to enable complete PS monitoring and control from the remote Centralized SCADA center.

The typical data are to be transmitted by the Contractor to the interface on a minimum but not limited to:

- power outage hours / day (h);
- power outage at pumping station ;
- Complete plant maintenance record ;
- Complete plant operational data;
- All levels
- Gates & valves status

The minimum scope of work for ICA at each pumping station shall include but not be limited to:

- 1) Design, supply, install, test and commission a dual redundant PLC based SCADA system for each pumping station. The system shall include on a minimum , but not limited to process controller including its central process units (CPUs in redundant configuration), redundant communication modules, RIO's,16" Color touch screen HMI,

Simplex input-output (I/O) modules(Hot swappable), control networks, Redundant SCADA servers, and software, CCTV workstations and printers;

- 2)** All servers for SCADA, etc. shall be redundant .
- 3)** Design, supply, install, test and implementation of data communication to the remote centralized SCADA System inclusive of bulk data transfer of all operational data via redundant GPRS communication network.
- 4)** Design, supply, install, test and commission individual process systems RIO panels including its instrumentation and control system units and its interface with main plant PLC system; The process systems shall be furnished with individual RIO panels with RIO modules which shall communicate with the main plant PLC for monitoring and control .
- 5)** Design, supply, install, test and commission 10 KVA uninterrupted power supply system with 60 mins backup on full load, to supply the entire PLC based SCADA system including the Remote I/O (RIO) systems and field instrumentation,CCTV system, vendor packaged control system and associated instrumentation, communication interface consisting of GPRS modems;
- 6)** Design, supply, install, test and commission CCTV system including its interface with main plant SCADA system; The contractor shall install the CCTV cameras at all process locations .During construction ,the CCTV system shall be installed at all process locations/construction points and the CCTV feed shall be used to monitor the project progress from remote location in real time. Contractor shall ensure that the CCTV feed is web based and can be accessed through standard web browsers. High speed broadband internet connection shall be utilized on site to relay the CCTV feeds as required for monitoring from remote locations.
- 7)** Control room furniture include but not limited to control system consoles for placing servers, workstations and printer compartments, and ergonomic designed seating systems.
- 8)** The Contractor shall be responsible for the design of each instrumentation and plant monitoring system, including the selection and design of appropriate transducers, transmitters, signal conditioning devices, indicators, alarm system programmable devices, communications, cable system etc. The Contractor shall take account in his design of all installation and environmental conditions prevailing at the site.
- 9)** All necessary required cabling, programming, software and hardware required to make the data available to the above mentioned contracts at all times, is part of the integral scope of work of the contractor. The contractor shall co-ordinate in full and conduct

interoperability tests with the centralized SCADA contractor to ensure data is compatible with the data format required.

20.12 SYSTEM COMPLETENESS

This section of specifications defines the particular requirements of instrumentation, control & automation works to be installed.

Irrespective of the detailed specifications of the respective items detailed in the various chapters of the tender specification, the Contractor shall be required to provide all the equipment, accessories, cabling, earthing, providing necessary transducers/sensors, system hardware/software, programming logic, interlocks ,cabinets, panels etc. to achieve the functional requirements described in the Bid Document.. The System completeness shall be the Contractor's responsibility.

Note: In FAT, all the field instruments shall be tested for functionality as per contract requirements at the manufacturers work location where the equipment is manufactured. Quality assurance plan (QAP) shall be submitted along with the datasheets for review and approval before any inspections call is initiated.

20.13 FIELD INSTRUMENTATION AND CONTROL

Each field instrument shall be operable in local mode and have display functions in SCADA. The Contractor shall be responsible for providing the appropriate signals at the locations required to provide the specified control and monitoring functions.

The Contractor shall ensure that field measuring systems shall respond quickly to any changes of the measured process variables.

All field instruments shall, as far as practicable, be mounted in a location that shall be free of vibration and shall be powered from the instrument control system.

24V dc power wiring for field instruments shall be individually fused and provided with a means of disconnecting the power without disturbing terminated wiring (e.g. knife-switch-type terminal blocks). Visual indication of a blown fuse condition shall be provided.

All field instrument components shall be of a proven and reliable design and shall have a high degree of uniformity and shall, wherever possible, be interchangeable. The design shall facilitate easy maintenance and repair, taking into account the availability of access routes through plant and structures generally.

Field Instruments shall perform sensing, indicating, transmitting and controlling. The devices shall generally interface with the SCADA, either directly or indirectly. The materials of those parts of the field instruments, including piping material, which are exposed to the measured media shall be compatible with the conditions of the respective media and of the ambient fluid and atmospheric conditions.

All field instruments shall be mounted within enclosures that are corrosion proof, dust proof and waterproof to provide a minimum protection specified in elsewhere in this Specification. The enclosure shall be rated to minimum IP 65.The enclosure design shall be submitted along with the instrument datasheet for review and approval before any design of the same.

All field instruments, including the components, shall be tropicalized and designed for the ambient conditions detailed elsewhere in this Specification. Lighting protection barriers shall be used for protecting transmitters and receiving instruments from the surge voltage due to lighting strike. Lighting protection barriers shall be supplied at both receiving and sending ends for all signals from outside building and those installed between the buildings.

20.14 INSTRUMENTATION DESIGN CRITERIA

The design criteria to be applied to instrumentation systems shall be as follows:

- 1) all instruments shall be suitable for continuous operation;
- 2) all transmitting instruments shall have a 4 - 20 mA linear output;
- 3) all digital outputs shall be volt free;
- 4) all instruments shall be designed for the ambient conditions of temperature and humidity;
- 5) all wetted parts of instruments sensors shall be non-corrosive and suitable for use with sewage;
- 6) all instrumentation systems for use out of doors shall be protected to IP 65;
- 7) all analogue displays shall be of the digital type with no moving parts utilising back lit liquid crystal diode LED technology;
- 8) instrumentation shall utilise solid state electronic technology and avoid the use where practical of any moving parts;
- 9) minimum maintenance requirement;
- 10) Instrumentation shall resume operation automatically on the application of power following a power failure.

Instrumentation systems shall be provided as detailed in the Employer's Requirements and as necessary for the efficient and safe operation of the pumping station.

The Contractor shall provide systems to measure any other parameter required for the efficient and safe operation of the treatment plant.

Instrumentation sensors shall be suitable for the environment in which they are expected to work. Sensor located in hazardous or potentially hazardous atmospheres shall be certified for use in these areas.

All Sensors shall be of self-cleaning type.

Instrumentation shall be selected and installed in accordance with the manufacturer's instructions. Wherever practical components of similar systems shall be interchangeable. Instrumentation converter units shall where practical be located in the associated MCC common control panel well away from any injurious effects of the process.

Digital systems shall be provided as detailed in the Employer's Requirements and as necessary for the efficient and safe operation of the treatment plant

The Contractor shall provide Plant to detect any other condition required for the efficient and safe operation of the pumping station works.

Levels shall be displayed as percentage full,

20.15 TEMPERATURE SCANNERS

Temperature scanner shall be provided to detect high temperature on motor and pump in order to generate tripping signals. The input signals to temperature scanner shall be derived from industrial type Pt-100 resistance temperature detectors provided in the motor windings, the Pump bearings, the Pump Casing and the motor bearings.

Note: The same shall be provide as part of pump performance monitoring system.

(a) General

Service	Pump and Motor winding/bearing/ casing temperature measurements
Quantity	As per process requirements
Range	As per process requirements

	Service	Motor winding and bearing and pump bearing temperature measurements for each pump motor in the raw water and clear water pumping stations
	Range	0 to 2000 C
	Type	Microprocessor based
	Mounting	On Instrument Control Panel (ICP) of respective pumping station
	Accuracy	0.2% of range
	Resolution	0.1o C
	Input Signal	From RTDs for each pump motor
	Display	LCD / LED display, 4 digit for data and 2 digit for channel No.
	Scanning rate	Selectable
	Communication port for interfacing with PLC system	RS-485 (With Modbus protocol)
	Set point	2 set points (high and very high) for group of channels. Minimum 3 groups of channels shall be provided. Separate relay required for each set point.
	Type of contacts	2 change over contacts for each set point
	No. of channels	12 Nos minimum. (6 Nos. for pump winding temperatures, 2 Nos. for motor bearing temperatures, 2 Nos. for pump bearing temperatures and 2 Nos. spare).
	Programming	Through keyboard mounted on the front facia
	Password facility	Required

20.16 LEVEL MEASUREMENT AND CONTROL

The following section describes the minimum technical specifications for level measurement and control under this contract. Ultrasonic level type measurement devices shall be used incorporating integral temperature compensation

Where foaming problems are identified as a local concern, the level measurement by level transducer shall be considered. Float switches are reserved as backup to the level indicating transmitters.

Sensing heads shall be mounted on 316 stainless steel brackets and positioned to ensure an unhindered beam path and ease of access for maintenance.

20.16.1 Ultrasonic Level transmitter:

	Transmitter	
1	Type	Ultrasonic
2	Principle	Pulse Time of flight
3	Output	4-20 mA HART current
4	Housing	Die Cast Aluminum
5	Electromagnetic compatibility	Interference emission to EN 61326; Equipment class B Interference immunity to EN 61326; Appendix A (Industrial)
6	Ingress Protection	IP68
7	Accuracy	+/- 2 mm or 4 mm depending on selection or 0.2% of set measuring distance Whichever is greater.
8	Area Classification	Non-Hazardous/Hazardous as applicable
9	Temperature range	-40°C ... +80°C
10	Display	4 line LCD display. Menu guided operation Display of Envelope curve.
11	Configuration	Using Keypad on display
	Sensor	
12	Range	Liquids 0 to 5m and 0 -10m depending on Tank size
13	Temperature range	-40°C ... +80°C
14	Max Pressure	3 bar abs
15	Materials	Sensor: PVDF Seal: EPDM
16	Process connection	Threaded or universal flange dependent on model selection
17	Degree of protection	IP68

20.16.2 Float Switches

- 1) Level switches of the buoyancy type shall consist of a non-mercury switch with changeover action enclosed in a non-corrodible material. A balance weight shall also be incorporated in the switch to counteract the buoyancy effect of the specific gravity of the particular fluid. The connecting cable shall be factory sealed to the switch. The switches shall be installed in a stiller tube in the wells.

- 2) Level switches shall be installed with a minimum of 3 m of spare connecting cable neatly coiled at a supporting bracket. The connecting cable fixing shall facilitate any alteration in operating level within the limit of the spare cable.
- 3) The level switches shall act as backup to the level transmitter in the control interlock sequence.

20.16.3 Level Gauge (Float & Tape)

1) Type	:	Float and Tape
2) Float & Tape MOC	:	AISI 316
3) Pulley Housing	:	Aluminum
4) Guide wire	:	SS 316 Stainless steel
5) Accuracy	:	+/- 2 mm
6) Indication	:	On circular or vertical dial
7) Rating	:	Twice the design pressure

20.16.4 Capacitance type level measuring system

(i) Level Transmitter

a. Service	:	Surge vessel level measurement
b. Quantity & Range	:	As per process requirements
c. Mounting	:	From top of stand pipe
d. Zero span adjustment	:	Required
e. Accuracy	of	$\pm 1\%$ of full scale measuring loop
f. Output signal	:	4-20 mA

20.16.5 Conductivity type level switches

(i) General

a. Service	:	Clear water reservoirs, Surge vessel, and surge tank level detection
b. Quantity & Range	:	As per process requirements

(ii)

Conductivity Probes

a.	No. of electrodes	As per application
b.	Probe insulation	Teflon
:		
c.	Mounting	Flanged (From top)
:		
d.	Probe head housing	Aluminium
:		
	material	
e.	Spacers between electrodes	Required
:		
f.	Stilling pipe	Perforated PVC/HDPE
:	pipe	

(iii) **Level Controller**

Input		From conductivity probe
:		
a	Switch	contact
:		
	(for each setting)	
b	Contact	rating
:		
c	Sensitivity	control
:		Required
	Mounting	Field
	Protection class	IP-65 of IS 13947 Part 1

20.17 FIRE ALARM & SUPPRESSION SYSTEM

The contractor shall provide Fire Suppression system for the control Room, electrical MCC room, other electrical areas, FOC equipment room and administration building covering all areas and Fire Alarm Systems capable of detecting smoke or heat or if someone operates a break glass unit (manual break point), consisting the following components:

1. SPECIFICATION FOR FIRE DETECTION AND ALARM SYSTEM

- A. The control panel, to be intelligent device addressable, analog detecting, low voltage and modular, with digital communication techniques, in full compliance with all applicable codes and standards. The features and capacities described in this specification are required as a minimum for this project and shall be furnished by the successful contractor.
- B. The system shall be in full compliance with National and Local Codes.
- C. The system shall include all required hardware, interconnecting wiring and software to accomplish the requirements of this specification and the contract drawings, whether or not specifically itemized herein.
- D. All equipment furnished shall be new and the latest state of the art products of a single manufacturer, engaged in the manufacturing and sale of intelligent fire detection devices for over ten years.
- E. The system as specified shall be supplied, installed, tested and approved by the local Authority Having Jurisdiction.

2. Qualifications of vendor/system integrator:

- A. The contractor shall submit vendor credentials for review and approval. The vendor/system integrator shall have completed successfully at least three fire alarm system of similar type (same scope, type and design) as required under this contract during the last five years. Completion certificates for each shall be submitted as part of credential submission.

3. Manufacturer's Representative:

- 1. The contractor shall provide the services of a factory trained and certified representative or technician, experienced in the installation and operation, maintenance and service of the type of system provided. Details of the same shall be provided for review and approval. The technician shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system and interface with the plant SCADA system for monitoring of the system. The technician shall provide the required instruction to the contractor personnel in the system operation, maintenance and programming.

4. Submittal:

- A. The contractor shall include the following information in the equipment submittal:
 - 1. Power calculations. Battery capacity calculations.
 - 2. NAC circuit design shall incorporate a 30 % spare capacity for future expansion.
 - 3. Complete manufacturers catalog data including supervisory power usage, alarm power usage, physical dimensions, and finish and mounting requirements.

5. System Requirements:

- A. The system shall be a complete, electrically supervised fire detection and notification system, microprocessor based operating system having the following; capabilities, features and capacities:
1. The local system shall provide status indicators and control switches for all of the following functions:
 - a) Audible and visual notification alarm circuit zone control.
 - b) Status indicators
 - c) Any additional status or control functions as indicated on the drawings, including but not limited to; emergency generator functions, fire pump functions, door unlocking and security with bypass capabilities.

Each intelligent addressable device or conventional zone on the system shall be displayed at the fire alarm control panel by a unique alphanumeric label identifying its location.

6. System Operation:

- A. Activation of any system fire, security, supervisory, trouble, or status initiating device shall cause the following actions and indication to display in the panel.
1. Log to the system history archives all activity pertaining to the alarm condition.
 2. Print to system printer (where required) alarm condition information.
 3. Sound the ANSI 117-1 signal with synchronized audibles and synchronized strobes throughout the facility.
 4. Audible signals shall be silenced from the fire alarm control panel by an alarm silence switch. Visual signals shall be programmable to flash until system reset or alarm silencing, as required.
5. The heat detectors shall be rated suitably at a temperature below the Permissive limits.
- B. Supervisory Condition:
1. Display the origin of the supervisory condition report at the local fire alarm control panel graphic display.
 2. Activate supervisory audible and dedicated visual signal.
 3. Audible signals shall be silenced from the control panel by the supervisory acknowledge switch.
 4. Record within system history the initiating device and time of occurrence of the event.
 5. Print to the system printer (where required) the supervisory condition.

D. Trouble Condition:

1. Display at the local fire alarm control panel graphic display, the origin of the trouble condition report.
2. Activate trouble audible and visual signals at the control panel and as indicated on the drawings.
3. Audible signals shall be silenced from the fire alarm control panel by a trouble acknowledge switch.
4. Record within system history, the occurrence of the event, the time of occurrence and the device initiating the event.
5. Print to the system printer (where required) the trouble condition.

E. Security Condition:

1. Display at the local fire alarm control panel graphic display, the origin of the security condition report. A dedicated security LED shall flash until the alarm has been acknowledged, then revert to a steady "ON" state.
2. The control system shall be capable of bypassing the alarms from an individual security system installed within selected areas. The pass code allowing this function shall be assignable to individual security personnel and each bypass action shall be logged to system history. Intrusion alarms occurring during a bypass period shall be logged to history and displayed but no audible alarm shall occur at the control panel.
3. Print to the system printer (where required) the security condition.
4. The Local Fire Control Panel shall be "UL" 1076 listed for security purposes.

7. Equipment Particular Requirements

a) Control Panel:

- A. The fire alarm control panel shall be microprocessor based throughout the system providing rapid processing of smoke detector and other initiation device information to control system output functions. Problems with either the processors or the system program shall activate a trouble signal, and reset the panel. All module wiring shall be to terminal blocks, which will plug into the system card cage. The blocks shall be color coded to prevent accidental crossing of wiring.
- B. The basic system shall have capabilities for 252 intelligent initiation devices. The system shall employ a flexible number of detection input loops to reach maximum system capacity.
- C. The Device Loop Card shall be capable of minimum 252 intelligent devices. Any trouble on one circuit shall not affect the other circuit. This module shall also provide the signaling to the field devices for controlling the output of specific initiation devices. The circuit shall be capable of being connected with polarity insensitive intelligent initiation devices. The circuits shall have the ability to be wired, Style 4, Style 6. Any of all of the 252 devices on the loop card shall be capable of activating up to two devices (relay base, audible base or remote lamps). These accessories

shall not take away from the 252 addresses available. The on board microprocessor provides the loop card with the ability to function even if the main microprocessor fails. LED's on the board shall provide annunciation for the following; Power, Card Failure, Ground. Fault, Alarm, Trouble, Short Zone 1, Short Zone 2, Style 6 Open Zone 1, Style 6 Open Zone 2. This card shall plug into the system card cage.

- D. The Signal Line Circuits shall be tested for opens, shorts, ground faults, device status and multiple device response (2 devices at same address) and communications with all addressable devices installed before connection to the control panel. Systems without this capability shall have a test panel installed for initial testing to eliminate any possible damage short term or long term to the control panel. After initial testing replace the test panel and proceed with complete testing.
- F. The system also shall have four class B or 2 class A Notification Appliance Circuits built into the main board.

b) System Enclosures:

- A. Provide the enclosure needed to hold all the cards and modules as specified with at least spare capacity for two cards. The enclosures shall be either black or red. The outer doors shall be capable of being a left hand open or a right hand open. The inner door shall have a left hand opening. System enclosure doors shall provide where required ventilation for the modules or cards in the enclosure.

c) Intelligent Initiation Devices:

- A. All initiation devices shall be insensitive to initiating loop polarity. Specifically, the devices shall be insensitive to plus/minus voltage connections on either Style 4 or Style 6 circuits.
- B. The smoke detector shall be an intelligent digital photoelectric detector with a programmable heat detector. Detectors shall be listed for use as open area protective coverage, in duct installation and duct sampling assembly installation and shall be insensitive to air velocity changes. The detector communications shall allow the detector to provide alarm input to the system and alarm output from the system within four (4) seconds. Detectors shall be programmable as application specific, selected in software for a minimum of eleven environmental fire profiles unique to the installed location. These fire profiles shall eliminate the possibility of false indications caused by dust, moisture, RFI/EMI, chemical fumes and air movement while factoring in conditions of ambient temperature rise, obscuration rate changes and hot/cold smoke phenomenon into the alarm decision to give the earliest possible real alarm condition report. The intelligent smoke detector shall be capable of providing three distinct outputs from the control panel. The system controlled output functions shall be from an individual or unique input of smoke obscuration, a thermal condition or a combination of obscuration and thermal conditions. The detector shall be designed to eliminate calibration errors associated with field cleaning of the chamber. The detector shall support the use of a relay and LED remote indicator at the same time. Low profile, white case shall not exceed 2.5 inches of extension below the finish ceiling. Detector wiring shall not require any special shielded cable.
- C. Thermal Detectors shall be rated at 135 degrees fixed temperature and 15 degrees per minute rate of rise. Detectors shall be constructed to compensate for the thermal lag inherent in conventional type detectors due to the thermal mass, and alarm at the set point of 135 degrees Fahrenheit. The choice of alarm reporting as a fixed

temperature detector or a combination of fixed and rate of rise shall be made in system software and be changeable at any time without the necessity of hardware replacement. The detectors furnished shall have a listed spacing for coverage up to 2,500 square feet and shall be installed according to the requirements of NFPA 72 for open area coverage.

- D. The smoke detector shall be an intelligent digital photoelectric detector with a programmable heat detector. Detectors shall be listed for use as open area protective coverage, in duct installation and sampling assembly installation and shall be insensitive to air velocity changes. The detector communications shall allow the detector to provide alarm input to the system and alarm output from the system within four (4) seconds. The detector shall be mounted in a duct detector housing listed for that purpose. The duct detector shall support the use of a remote test switch, relay or LED remote indicator. The duct detector shall be supplied with the appropriate sampling tubes to fit the installation. Where duct detectors are exposed to the weather provide a weatherproof enclosure.
- E. Detector bases shall be low profile twist lock type with screw clamp terminals and self-wiping contacts. Bases shall be installed on an industry standard, 4" square or octagonal electrical outlet box.
1. Where selective localized control of electrical devices is required for system operation, furnish and install detector base with software programmed addressable relay integral to the base. The relay shall switch electrical loads within relay ratings, as indicated on the drawings. Operation of the addressable control circuit shall be independent of the number of detectors and relays on the circuit or the number in an alarm state.
 2. The contractor shall furnish detector base with integral approved audible evacuation alarm signal having an output of 85db. The audible signal shall be individually addressable and software programmed for operation.

d) Notification Appliances:

- A. The electronic chime or chime/strobe shall be a speaker with a tone card and have and adjustable range of 700 to 1300 Hz. The chime or chime/strobe shall be adjustable for either single stroke or continuous operation. The chime/strobe shall be available with adjustable strobe intensities of 15, 30, 75, and 110 candela. The appliance shall be red for wall mounted and white for ceiling mounted. Ceiling mounted appliances shall be rated for that application.
- B. Where required provide a 10" bell, to be connected to a non-silenceable circuit for activation of the sprinkler system.

8. EXECUTION

a) Installation:

- A. Perform work in accordance with the requirements of NFPA 70 and NFPA 72.
- B. Fasten equipment to structural members of building or metal supports attached to structure, or to concrete surfaces.

b) Boxes, Enclosures And Wiring Devices:

- A. Boxes shall be installed plumb and firmly in position.
- B. Extension rings with blank covers shall be installed on junction boxes where required.
- C. Junction boxes served by concealed conduit shall be flush mounted.
- D. Upon initial installation, all wiring outlets, junction, pull and outlet boxes shall have dust covers installed. Dust covers shall not be removed until wiring installation when permanent dust covers or devices are installed.
- E. "Fire Alarm System" decal or silk-screened label shall be applied to all junction box covers.

c) Conductors:

- A. Each conductor shall be identified with wire markers at terminal points. Attach permanent wire markers within 2 inches of the wire termination. Marker legends shall be visible.
- B. All wiring shall be supplied and installed in compliance with the requirements of the National Electric Code, NFPA 70, Article 760, and that of the manufacturer.
- C. Wiring for strobe and audible circuits shall be a minimum 14 AWG, signal line circuits shall be minimum 18 AWG.
- D. All splices shall be made using solderless connectors. All connectors shall be installed in conformance with the manufacturer recommendations.
- E. Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.
- F. Permanently label or mark each conductor at both ends with permanent alphanumeric wire markers.
- G. A consistent color code for fire alarm system conductors throughout the installation.
- H. The installation contractor shall submit for approval prior to installation of wire, a proposed color code for system conductors to allow rapid identification of circuit types.
- I. Wiring within sub panels shall be arranged and routed to allow accessibility to equipment for adjustment and maintenance.

d) Devices:

- A. Relays and other devices to be mounted in auxiliary panels are to be securely fastened to avoid false indications and failures due to shock or vibration.
- B. Wiring within sub-panels shall be arranged and routed to allow accessibility to

- equipment for adjustment and maintenance.
- C. All devices and appliances shall be mounted to or in an approved electrical box.

e) Certificate of Compliance:

Complete and submit to the Engineer in accordance with NFPA 72, 1999 edition section 1-6.2(latest version).

f) Field Quality Control:

Testing, general

1. All Alarm Initiating Devices shall be observed and logged for correct zone and sensitivity. These devices and their bases shall be tagged with adhesive tags located in an area not visible when installed, showing the initials of the installing technician and date.
2. Wiring runs shall be tested for continuity, short circuits and grounds before system is energized. Resistance, current and voltage readings shall be made as work progresses.
3. A systematic record shall be maintained of all readings using schedules or charts of tests and measurements. Areas shall be provided on the logging form for readings, dates and witnesses.
4. The engineer shall be notified before the start of the required tests. All items found at variance with the drawings or this specification during testing or inspection shall be corrected.
5. Test reports shall be delivered to the acceptance inspector as completed.
6. The installing contractor shall make instruments, tools and labor required to conduct the system tests available.
7. The following equipment shall be a minimum for conducting the tests:
 - a) Ladders and scaffolds as required to access all installed equipment.
 - b) Multimeter for reading voltage, current and resistance.
 - c) Two way radios and flashlights.
 - d) A manufacturer recommended device for measuring airflow through air duct smoke detector sampling assemblies.
 - e) Decibel meter.

g) Acceptance Testing:

- A. A written acceptance test procedure for testing the fire alarm system components and installation will be prepared by the contractor in accordance with NFPA 72 and this specification. The contractor shall be responsible for the performance of the system, demonstrating the function of the system to the END USER and verifying the correct operation of all system components, circuits, and programming.

- B. A program matrix shall be prepared by the installing contractor referencing each alarm input to every output function affected as a result of an alarm condition on that input.
 - C. The installing contractor prior to the test shall prepare a complete listing of all device labels for alphanumeric annunciator displays.
 - D. The items tested shall include but not be limited to the following:
 - System wiring shall be tested to show the following results and the system subsequence operation:
 - Open, Shorted or Grounded Circuits.
 - Complete functioning of the system.
- h) Primary and Battery power disconnected.

System notification circuits and appliances operate as programmed. Audibility and Visual levels meet required standards. System shall demonstrate the correct messages at the FACP and Remote Annunciator. System off site reporting shall be verified for alarm, supervisory and trouble. System shall be tested for stand-by battery back up as outline in this specification.

Portable Fire Extinguishers-General

Adequate no of Fire extinguishers as per site condition shall be provided in each room for putting off fires of small in nature. Fire extinguishers are divided into four categories, based on different types of fires. Each fire extinguisher also has a numerical rating that serves as a guide for the amount of fire the extinguisher can handle.

20.18 PARTICULAR CONTROL & AUTOMATION REQUIREMENTS

20.18.1 General

This part covers the Particular requirements for the design, supply, installation, Inspection and testing of Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA) and associated plant and materials.

20.18.2 Panel HMI

The panel HMI shall be with 16" Color screen and with touch screen capabilities.

All Remote I/O panels which are connected to the main plant PLC based SCADA system shall be equipped with a panel HMI .The HMI shall be suitable for day to day operation by non-computer literate personnel in the monitoring and operation of the pumping station works.

The HMI shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimization. The system will allow operators, technicians and Employer Representatives to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the particular system. HMI unit along with software packages shall be considered, and also those software packages and Hardware shall be compatible with TCP / IP protocols as well as OPC communication (Open Standard Communication)

20.18.3 Design and Construction Requirements

In particular, the following configuration shall be applicable across the pumping station. PLC shall be provided as a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities

Main Plant PLC: Hot standby PLC

Main PLC system shall comprise of necessary hot standby PLC processors, Simplex input/output (I/O) modules(duplex I/O modules shall be provided for only critical inputs/outputs, the same shall be decided during detail design engineering), redundant communication interface modules, redundant power supply modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications. PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

All PLC ,SCADA & RIO Systems shall be housed in air conditioned environment. The contractor shall submit the sizing calculations for the air conditioning system for review and approval.

The contractor shall refer the approved vendor list for the PLC system and hardware, elsewhere in this document.

Remote input/output modules (RIO)/Panels

Individual Process locations: RIO panel with redundant RIO modules and power supply and communication modules, with simplex I/O modules (duplex IO's shall be considered for critical inputs and outputs). The control system shall be furnished with individual RIO panels (if required) with RIO modules which shall communicate with the main plant PLC for monitoring and control. Minimum 16" Color panel mounted HMI with touch screen functionality shall also be provided for all RIO panels. It shall be possible to view and acknowledge the alarms and view set points for the particular process and the subsequent processes from the HMI for monitoring and control.

I/O Modules:

Standard rack mounted plug in I/O modules shall be provided. I/O Modules shall be of the same series as the PLC CPU. Refer the approved vendor list for the PLC system and hardware, elsewhere in this document. All I/O modules shall be hot swappable.

Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules shall be hot swappable. 50 % extra modules of installed capacity for each type of module shall be provided as spare and installed in the panel ,to cater to future expansion. In addition to the above, provision shall be made for future expansion of additional 30% extra I/O modules of the installed capacity in the panel. The panel drawings shall reflect the same.

I/O modules shall be as follows:

- a) inputs shall be opto isolated.;
- b) filters shall be provided for noise rejection;
- c) output status shall be indicated by an LED;
- d) all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
- e) all the modules shall be of addressable type.
- f) Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 Base T connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

Each PLC shall have memory protected built in historical archiving/data logging of system alarms & events and process variables. Data logger shall be able to log data based on time or an event. PLC shall have enough memory allocated to allow 200,000 time and data stamped discrete and /or analog values to be archived. The historical archive shall allow the oldest data to roll off the system as memory is used keeping the 200,000 most current data points available. Process point time stamping frequency shall be selectable within the configuration software. It shall be possible for the archived data to be exported in CSV format allowing use with standard spreadsheet and data software applications

The PLC system shall be expandable, OPC Compatible (OPC shall be a built in feature of the software and hardware. No external software patch or hardware module is allowed) and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

a) Dual Redundant Processors (CPU)

The master station shall be provided with two identical central processors configured such that they operate in Hot-Standby mode.

Redundant system with hot back up redundancy feature shall be built in the CPU. CPU shall have the memory expansion capability up to 7 MB.

SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity is to be provided. PLC CPU and I/O modules shall be of the same logic family.

The system shall be designed and implemented such that when the Main processor fails, the Standby one shall automatically take over. The changeover shall be seamless, smooth and

without any time delay and shall not cause any disruption to the overall distributed control system and to the ongoing processes.

The PLC system shall be expandable (OPC Compatible) and shall be modular in construction, so as to capable of future expansion without hardware modifications.

The system hardware, application software and database shall be sized to accommodate a total of 75% increase in signal capacity and up to 100% increase in an individual zone.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system. In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

CPU shall have a real time clock capability to accept a time synchronization pulse and adjust its internal clock with the pulse. CPU shall have extensive self-diagnostic facilities and watch dog timers to identify faults at card levels

Application logic programs shall be fully compliant with all five logic development methods detailed in IEC 61131-3. The PLC shall be powered by two independent sources provided by the UPS system and all internal operating supplies shall be derived from the UPS.

The power supplies, I/O modules, CPU and communication modules shall be monitored by the PLC and shall be available by report. The same shall be monitored on the SCADA screen.

During the times of the battery discharge, the PLC shall initiate an orderly self-shutdown and automatically restart on the main power restoration without the need for reloading or initiation of any kind. The PLC shall comply with the specification specified elsewhere in this specification.

b) Memory Unit

Memory unit shall comprise of highly reliable memory chips which are industry standard, proven design with fast random access and suitable for operation in process environments. Main memory shall be modular and facility shall be provided for the upgrading and expansion of memory to meet future demands.

Not less than 75 % spare program memory and data memory space shall be provided. System initialization and application software shall be stored in EEPROM or EPROM. Operating data shall be stored in a RAM fitted with an internal battery backup.

c) I/O Modules

Standard rack mounted plug in I/O modules shall be provided. I/O Modules shall be of the same series as the PLC CPU. Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules shall be hot swappable.

50 % extra modules of installed capacity for each type of I/O module shall be provided as spare and installed in the PLC panel. The same shall be demonstrated during FAT,

I/O modules shall be as follows:

- inputs shall be opto isolated.;
- filters shall be provided for noise rejection;

- output status shall be indicated by an LED;
- all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
- all the modules shall be of addressable type.
- Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 BaseT connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

d) Analogue Input Modules

They shall consist of an input isolation unit, signal conditioning unit and an analogue to digital converter (ADC). In addition, the following features shall be provided.

- cross talk attenuation
- provision for monitoring of the ADC for overflow detection
- gain amplifier with high common mode rejection ratio
- accuracy for analogue signals shall be 0.5%

e) Digital Input Modules

The following design features shall be provided.

- contact bounce protection;
- choice of type of contacts.

f) Digital Output Modules

The digital output module shall provide contact closure output by driving relays. The features to be provided are as follows:

- contact bounce protection shall be provided
- relay output shall be provided to operate pump motors and motorised valve actuators
- fail safe position in case of output module failure and fault indication

PLC's provided under this specification shall be capable of performing the necessary logic to control the system as previously defined. These capabilities shall include, but not be limited to the following:

1) Discrete input/output	10) Latch/unlatch relays
2) Analog input	11) Counters
3) Analog output	12) Comparators
4) Timers	13) Ladder logic
5) Pump Controller	14) Flow Totalization/ Integration
6) Pump Alternation	15) Intrusion Detection
7) Mathematical Function Blocks	16) Time of Day Control w/Lockout
8) Stage Blocks	17) Ramp Blocks
9) Trending	18) Data Logging

g) PLC Programming

PLC programming shall be carried using functional block diagrams (FBD). The logic shall be prepared using programming software and shall be comprehensively

annotated with subroutine and rung comments to assist further development and maintenance.

The contractor shall submit the details of the PLC programming software for review and approval.

The system shall support a simple programming of the application software comply with IEC 61131-3.

The system shall support a structured, modular programming. At least the following standard operations shall be applicable:

- 1) Logic functions (such as AND/OR/AND NOT etc.);
- 2) Timer functions (externally adjustable);
- 3) Counter functions;
- 4) Skip functions;
- 5) Comparison functions;
- 6) Limit value functions;
- 7) Arithmetic functions;
- 8) Physical unit functions;
- 9) Closed-loop functions such as P/PI/PID/etc.

The Contractor shall submit the logic diagrams for review. The Contractor shall include the as-built logic in the final submission.

h) Ethernet Switches

The contractor shall only provide managed industrial grade Ethernet switches under this contract. All switches shall be in redundant configuration.

20.19 MINIMUM I/O REQUIREMENTS FOR AUTO MODE CONTROL OPERATION OF THE PLANT:

On a minimum, the control design shall incorporate the I/O requirements which are indicated in the table. All process & Instrumentation Diagrams (P&ID) shall incorporate & depict the minimum I/O requirements as indicated in the table below.

Design shall include complete auto mode of operation of the entire pumping station and associated plants/stations with all necessary interlocks and safety mechanisms.

Minimum I/O to be provided under this contract for the Control system is as under:

SI No	TYPE	MINIMUM I/O'S TO BE CONSIDERED
1.	Pump, Motor	Start, Stop, Available, Auto, Off, Manual, Run, Emergency Stop, Fault, Speed ref
2.	Valve & gates	Available, ,Auto, Off, Manual, Open, Close, Travelling Indication, Fault
3.	Drives	Available, ,Start, Stop, Auto, Off, Manual, Run, Emergency Stop, Fault

4.	Level Indicator	HH, H, L, LL, Analog value,
5.	Level Switch	HH, H, L, LL,
6.	Pressure Indicator/transmitters	Shall be provided at (in addition to individual pumps, at common discharge end of pumps, etc...): Analog Value,
7.	Flow Indicator/Transmitters	Shall be provided at (in addition to other plant flows, at individual discharge end of pumps, etc...): Analog value, totalizer,

Typical Drive Control Philosophy to be provided on a minimum shall be as follows:

SL. NO.	DESCRIPTION	Type of I/O	No of I/O
1.	PLC INTERFACE FOR UNIDIRECTIONAL HT DRIVE / LT BREAKER CONTROL DRIVE (Signal Exchange has been envisaged between PLC and switchgear)		
a.	Start Command	DO	1
b.	Stop Command	DO	1
c.	ON Feedback	DI	1
d.	OFF Feedback	DI	1
	Auto, Off, Manual	DI	3
e.	Swgr. Disturbance (Overload relay operated/ control supply fail/	DI	1
	Emergency LPBS stop)	DI	1
	Available	DI	1
f.	Electrical Trip (Motor Protection Relay)	DI	1
g.	Switchgear Available (breaker in service position, switchgear in remote & breaker spring charged)—	DI	1
	Shall be as per PPM system. The following I/O are to be provided on a minimum		
h.	Pump bearing temperature measurement	AI	2

SL. NO.	DESCRIPTION	Type of I/O	No of I/O
i.	Motor Bearing temperature measurement	AI	2
j.	Motor Winding temperature measurement	AI	6
k.	Current Transducer input	AI	1
2.	PLC INTERFACE FOR UNIDIRECTIONAL LT DRIVE (Signal Exchange has been envisaged between PLC and PCC/MCC)		
a.	Start Command	DO	1
b.	Stop Command	DO	1
c.	ON Feedback	DI	1
d.	OFF Feedback	DI	1
	Auto, Off, Manual	DI	3
	Available	DI	1
e.	Swgr/MCC Disturbance (Overload relay operated/ control supply fail/	DI	1
	Emergency LPBS stop)	DI	1
f.	Switchgear/MCC Available (switchgear/MCC in remote)	DI	1
3.	PLC INTERFACE FOR BIDIRECTIONAL LT DRIVE- For Integral starters (Signal Exchange has been envisaged between Actuator and PLC.)		
a.	Open Command	DO	1
b.	Close Command	DO	1
c.	Integral starters Fault	DI	1
d.	Open limit switch feedback	DI	1
e.	Close limit switch feedback	DI	1
	Auto, Off, Manual	DI	3
	Available	DI	1
f.	Position Transmitter (For inching type Drive)	AI	1
g.	Command	AO	1
4.	PLC INTERFACE FOR BIDIRECTIONAL LT DRIVE-For Non-Integral starters (Signal Exchange has been envisaged between Actuator and PLC.)		
a.	Open Command	DO	1

SL. NO.	DESCRIPTION	Type of I/O	No of I/O
b.	Close Command	DO	1
	Auto, Off, Manual	DI	3
c.	Swgr/MCC Disturbance (Overload relay operated/ control supply fail/	DI	1
	Emergency LPBS stop)	DI	1
	Available	DI	1
d.	Switchgear/MCC Available (switchgear/MCC in remote)	DI	1
e.	Open limit switch feedback	DI	1
f.	Close limit switch feedback	DI	1
g.	Position Transmitter (For inching type Drive)	AI	1
5.	PLC INTERFACE FOR SOLENOID DRIVE (Single coil)		
a.	Energise or Deenergise	DO	1
b.	Open limit switch feedback	DI	1
c.	Close limit switch feedback	DI	1
6.	PLC INTERFACE FOR SOLENOID DRIVE (Double coil)		
a.	Energise	DO	1
b.	Deenergise	DO	1
c.	Open limit switch feedback	DI	1
d.	Close limit switch feedback	DI	1
7.	PLC INTERFACE FOR PNEUMATIC DRIVE		
a.	Command to I/P converter	AO	1
b.	Position Transmitter	AI	1
c.	Open limit switch feedback	DI	1
d.	Close limit switch feedback	DI	1
e.	Command to Solenoid valve (Wherever applicable)	DO	1

20.20 CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

Design, supply, install, test and commission CCTV system including its interface with main plant SCADA system; The contractor shall install the CCTV cameras at minimum 5 locations (to be decided during detailed engineering). During construction, the CCTV system shall be installed at all locations/construction points and the CCTV feed shall be used to monitor the project progress from remote location in real time. Contractor shall ensure that the CCTV

feed is web based and can be accessed through standard web browsers in real time. The contractor shall supply and maintain High speed broadband internet connection, which shall be utilized on site to relay the CCTV feeds as required for monitoring from remote location .

The contractor shall be responsible for the detailed design, supply, installation, testing and commissioning and training of Employer's staff of Closed Circuit Television (CCTV) system to be installed in the SCADA control room & at all locations in the plant. The CCTV system shall be designed to have complete coverage of the plants.

The scope shall include all necessary cabling, indoor & outdoor cameras and lenses, camera housing, TV monitor, control and interface units, coaxial cable transmission, video switching unit, time-lapse video recorders and tapes, junction boxes, power supplies, mounting brackets, etc, as required to provide a cost effective and reliable and fully operational CCTV system complying with the specification and to the approval of the Employer's Representative.

The CCTV system shall incorporate all equipment necessary to enable all areas to be viewed from the CCTV station monitor. The CCTV monitoring system shall be of latest design incorporating all the power and signal wiring as per manufacturer's standard. The system shall be complete package of one supplier of equipment, fixings, wiring conducting and all items necessary for a complete installation.

Materials

20.20.1 Cameras

Cameras shall be digital high resolution colour cameras having 1/3 inch CCD 450 TV lines with lens and an interlace of 2:1 in the scanning system of high excellent quality and performance utilising latest digital technology of super colour reproduction with low light high sensitivity down to 5 lux with electronic shutter speeds 1/50 to 1/30000 seconds .

Cameras shall be provided with a 14mm automatic lens with/without "drive" (amplifier) for 1/2" sensors, F1.4 CS mount, 22° angle shot and a composite video output at 75 ohms lines and the useful illumination range shall be 1.5 lux.The camera lens shall be of the auto iris zoom type with spot filter providing automatic control throughout the iris range from fully open F1.4, the lens shall incorporate a shutdown mechanism to protect the camera from high light level during periods of not in use. A neutral density filter designed to maintain image detail and contrast shall be incorporated in the lens. The output signal shall be of PAL. The Camera shall be suitable for the specified environmental conditions.

The camera shall be provided complete with all accessories required. The camera shall have the following features.

1. Program modes 1.5, 3, 6 minutes;
2. Variable scan speed between 1.40° per second;
3. Programmable limit stops for auto/random/frame scan modes;
4. Series protocols BS-422 'P' series and 'D' series;
5. Built-in menu system;
6. Pan movement – 360° continuous pan rotation;
7. Vertical tilt - Unobstructed +2 to +92°;

8. Variable pan/tilt speed controller;

9. Preset speeds:

Pan – 250°/sec

Tilt – 100°/sec

10. Electrical input – 24V AC.

20.20.2 Monitor

The monitor shall be of high resolution type suitable for CCTV system and shall comply with the following:

1. LED Screen: 32 dual monitor";
2. Power Supply: 240V, 50Hz;
3. Resolution : 420 lines;
4. Bandwidth : 5 MHz ($\pm 3\text{dB}$);
5. Video Input : 1 Vpp 75ohm;
6. Input/Output: BNC Video connector;
7. Front Controls: Power ON/OFF;
Brightness Control;
Contrast Control;
Colour Control.

20.20.3 Matrix Switcher

The matrix switcher shall be micro-processor based and provide switching and control for 16 video inputs and up to 4 monitor outputs from any one keyboard. The unit shall be remotely operated by desk-top key boards or external computer systems. The switcher shall have on-screen menu programming. The switcher shall support two system macros or salvo sequences to allow quick call-up of up to four cameras to four monitors simultaneously.

The salient features of the switcher shall be as follows:

1. 16 volts inputs; 2 or 4 video outputs;
2. 20-character camera title;
3. Time (24-hour or AM/PM formats), Date (4 formats);
4. Video inputs individually detectable for terminating or looping;
5. Individual monitor sequential switching with preset cell;
6. Compatible with RS 422 protocol;
7. Camera control selection;
8. Full duplex RS485 keyboard communications;
9. Selectable data port – RS 232/RS 422/RS 425;
10. Password protected menu programming;

11. User partitioning to prevent unauthorised viewing.

20.20.4 Receiver

The receiver shall operate on the principle of transmitting of transferring control information and video data on the same line. Standard control features shall include pan/tilt control, camera power, zoom lens control (zoom, iris, and focus with adjustable speed). The receiver shall be compatible with control systems utilizing standard 15-bit command protocols. Auto random scan capability or preset positioning shall be possible.

The test local control module shall allow on-site testing of system functions.

The salient features of the receiver shall be as follows:

1. Input power – 240V 50Hz AC;
2. Control method – 15 pulse train superimposed on the video signal;
3. Pulse amplitude – approximately 1 Vp-p added to video signal, 333kHz nominal;
4. Connectors – two BNC connector for video input and output one 37pin Amp CPC for control output;
5. Input video level – 1 Vp-p nominal, 2 Vp-p maximum;
6. System band width – Less than 2dB down at 10 MHz;
7. Fuse protection – 3 AG type;
8. Power chord – 3 wire grounded 18 AWG;
9. Operating distance – RG 11 at 1828 m;
10. Ambient temperature –20 to + 60°C.

The receiver shall be UL listed and shall comply with NEMA 4X and be CE compliant.

20.20.5 Amplifier

The video amplifier shall be of solid state circuitry and is meant for post equalization application only. The amplifier shall provide effective means of maintaining CCTV picture quality with RG11 coaxial cable.

The general construction of the amplifier shall consist of cover, chassis and panel.

The salient features of amplifier shall be as follows:

1. Input voltage – 240V AC;
2. Power transformer – 1.5VA (1.25 AMP) at 12 ±15% volts, 50Hz;
3. Input – Single BNC internally terminate in 75ohms;
4. Outputs – Single BNC source terminated;
5. Gain – Adjustable from 1 to 8dB;
6. Frequency response – Adjustable from flat (±1dB) at 12 MHz, greater than 18dB of boost at 12 MHz;
7. Output dynamic range – Up to 2 volts p-p at 50% APL;
Up to 1.5 volts p-p at 90% APL.
8. Cable length – RG 11 – 1828.8M;
9. Ambient temperature – 0° to 48.89°C at 0 - 90% RH.

The amplifier shall be UL listed to standard 2044 and comply with NEMA 1 and be CE compliant.

20.20.6 Time Lapse Video Cassette Recorder or Disk recorder

The time-lapse VCR/disk recorder shall be designed to suit multiple use. The recording capability shall enable continuous coverage over a long period of time with minimum tape changes.

Recording mode shall include standard VHS2 and 6-hour real time modes in addition to high density 18-hour linear real time recording. SP and EP recording modes shall make increase field recoding rate using standard high quality T120 VHS tapes.

The programming menu shall appear on the monitor output to provide easy setup of any programme feature. A lock mode shall disable all front panel controls presenting all changes to the unit's programming or operation. Playback features shall include speed search and reverse play back. Automatic alarm search feature shall allow the operator to go to a specific alarm index.

The salient features of disk recorder shall be as follows:

1. Standard VHS 2/6 hour recording mode;
2. 18/24/218/72/96/120/168 hour VHS compatible time-lapse modes;
3. Internal / short recording mode;
4. 24 hours real time recording mode;
5. High density record mode – triple speed time lapse recording;
6. Audio recording up to 24 hours;
7. Alarm index search;
8. Jog/shuttle for easy forward and reverse field playback and search;
9. On-screen menu programming;
10. Eight daily/weekly reading schedules.

20.20.7 CCTV Integration

A Close Circuit Television Camera's (CCTV) based on IP standard should be amenable to be integrated with the SCADA system.

Broadband internet services with high speed connectivity shall be used for data communication from CCTV monitoring locations to the CCTV server. The most suitable package of high speed broadband internet service provided by an Internet Service Provider (ISP) which suits the Client's requirement for high speed real time monitoring thru the CCTV shall be utilized. The contractor shall enter in to SLA agreement to provide continuous fail safe services as required under this contract.

20.21 APPROVED VENDOR/MANUFACTURER/MAKE LIST-CCTV

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired

CCTV systems	<ol style="list-style-type: none">1. M/S SONY2. M/s HITACHI3. M/S YOKO INTERNATIONAL4. M/s SANYO5. M/S AVTEL6. M/S MOBOTIX7. M/S JMACS8. M/S PYROTECH WORKSPACE
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20.22 RECOMMENDED VENDOR/MANUFACTURER/MAKE LIST-INSTRUMENTATION

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

Sr. No.	Description	Vendor/Manufacturer/Make
1	LEVEL INDICATOR TRANSMITTER	M/S ABB-GERMANY M/S ENDRESS+HAUSER M/S YOKOGAWA M/S SIEMENS M/S ROYCE INSTRUMENTS M/S HITACHI HIGH-TECH
2	LEVEL/FLOAT SWITCHES	M/S ABB-GERMANY M/S ENDRESS+HAUSER, M/S KROHNE GMBH GERMANY M/S LEVCON, M/S HITACHI HIGH-TECH
3	UN-INTERRUPTIBLE POWER SUPPLY SYSTEMS	M/S NIPPON KEIDENKI WORKS M/S FUJI ELECTRIC M/S HITACHI M/S MEIDENSHA CORPORATION M/S APC M/S FURUKAWA BATTERY M/S DELTA
4	BATTERIES	M/S SANKEN ELECTRIC M/S AMCO M/S EXIDE M/S SEC M/S FURUKAWA BATTERY
5	PANELS	M/S RITTAL M/S ELDON M/S CEPL M/S HOFFMAN M/S BCH
6	CABLES	M/S UNIVERSAL CABLES M/S HAVELL'S M/S CCI M/S FINOLEX

Sr. No.	Description	Vendor/Manufacturer/Make
		M/S NICCO M/S DELTON CABLES LIMITED

Note-1: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

Note-2: All products shall be completely manufactured in the country of Origin as indicated. Assembled products shall not be accepted.

Note-3: In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following during detailed engineering:

- 1) Demonstrate that the proposed makes are "Superior / Equivalent" to the approved makes.
- 2) Submit ISO certificates for the OEM.
- 3) Submit quality certificates that the equipment adheres to.
- 4) Submit product brochures for the proposed equipment.
- 5) Manufacturer involved in manufacture of specified equipment for at least 10 years before bid date
- 6) At least 10 successful individual installations of similar size as per this contract with the proposed equipment and model no, commissioned in last 5 years before bid date and satisfactorily operating for at least five years before bid date.
- 7) Manufacturer to provide full contact information for each reference as part of technical bid.

20.23 RECOMMENDED VENDOR/MANUFACTURER/MAKE LIST-AUTOMATION

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

Sr. No.	Description	Manufacturers/Makes		
1	WORKSTATIONS, SERVERS, LAPTOP NOTEBOOK	M/S-DELL M/S-HP M/S-FUJITSU M/S-TOSHIBA		
2	PROGRAMMABLE LOGIC CONTROLLERS & IO MODULES	Make	CPU Series	IO Series
		SCHNEIDER ELECTRIC	QUANTUM SERIES	QUANTUM 140 SERIES
		SIEMENS	S7-400H	ET-200M SERIES
		ALLEN BRADLEY	CONTROL LOGIX 1756	CONTROL LOGIX 1756

		SERIES	SERIES
	MITSUBISHI ELECTRIC	Q12PRH	Q SERIES
	OMRON	CS1D	CS1D SERIES
	ABB	AC 800 M	S 800 SERIES
3	SCADA SOFTWARE PROGRAMMING	WIN CC, RS VIEW, CITECT, MC WORKS, CX-SUPERVISOR, ABILITY SYMPHONY PLUS (All software's shall be Inclusive of reporting, web server, Trends and supporting industry standard multiple protocols, inclusive of OPC gateway support) Note: All software's shall be of the latest series version and shall include both runtime and developer versions.	
4	REMOTE TERMINAL UNIT	M/S-SIEMENS, M/S-ABB, M/S-MITSUBISHI, M/S-OMRON, M/S-TOSHIBA	
5	DC POWER SUPPLY	M/S-APLAR, M/S-WAGO, M/S-PHOENIX CONTACT, M/S-MEAN WELL, M/S-WEIDMULLER, M/S-OMRON. M/S-SHAVISION	
6	PANEL HMI	M/S-ADVANTECH, M/S-MITSUBISHI, M/S-PANASONIC, M/S-SIEMENS, M/S-M/S-ABB, M/S-OMRON. M/S-TOSHIBA	
7	LED MONITORS/DISPLAYS/VDU	M/S-SAMSUNG, M/S-LG, M/S- SONY, M/S-DELL, M/S-BENQ, M/S-HP	
8	PRINTERS	M/S- CANON, M/S- FUJI, M/S- XEROX, M/S-EPSON, M/S-RICOH	
9	CONTROL ROOM CONSOLES& FURNITURE	M/S PYROTECH WORKSPACE, M/S EVANS, M/S QUEST, M/S CEPL	

Note-1: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

Note-2: All products shall be completely manufactured in the country of Origin as indicated. Assembled products shall not be accepted.

Note-3: In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following during detailed engineering:

- 1) Demonstrate that the proposed makes are "Superior / Equivalent" to the approved makes.
- 2) Submit ISO certificates for the OEM.
- 3) Submit quality certificates that the equipment adheres to.
- 4) Submit product brochures for the proposed equipment.
- 5) Manufacturer involved in manufacture of specified equipment for at least 10 years before bid date

- 6) At least 10 successful individual project installations of similar size and application as per this contract with the proposed equipment and model no, commissioned in last 5 years before bid date and satisfactorily operating for at least five years before bid date.
- 7) Manufacturer to provide full contact information for each reference as part of technical bid.

20.24 SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA)

The SCADA shall be a fully integrated microprocessor based control and data acquisition system which will monitor, control, display, record and trend all assigned plant inputs and outputs. The SCADA shall be a fully dual redundant microprocessor based computer system such that reliable and automatic plant control can be achieved.

The main process monitoring and control shall be by means of VDU based process operator workstations that shall be located in the central control room.

SCADA system would be dual redundant server system. The system shall be designed and implemented such that the failure of a central processor or HMI console does not inhibit continuous automatic control of the plant.

Failure of a single outstation or communications to that outstation shall not effect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the non-failed outstations shall revert to a fail-safe mode.

An alarm shall be generated whenever a communications system failure occurs.

The SCADA control system shall comprise on a minimum the following but not limited to:

- a) Dual redundant SCADA servers with SCADA software with minimum five thousand tags license and web servers;
- b) Each SCADA server station shall be loaded with SCADA software and with latest licensed Windows server 2019 Operating system, minimum 2 TB storage, latest processor, etc.
- c) CCTV Monitoring station loaded with required software& hardware and with latest Windows Operating system, minimum 2TB storage, latest processor, etc
- d) One number of 65" touch screen LED display with controller connected over LAN to the SCADA system to display the process screens, alarms & reports, CCTV feeds, etc.
- e) Redundant industrial managed Ethernet switches
- f) Licensed MS Office ,Adobe licensed PDF Viewer & Antivirus software to be loaded on each system

- g) Industrial grade control system console to house the entire PLC based SCADA system and other equipment as indicated in the system configuration diagram.
- h) All required software and hardware to implement the system as indicated in the specifications and system configuration drawings.

The SCADA system shall follow the International Standards Organization (ISO), Open Systems Interconnect (OSI), reference model guidelines. All central system hardware and software devices shall be interconnected using a bus topology data highway. The communications protocol used shall generally meet the requirements of the ISO.

The system shall provide efficient and safe operation of the complete plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all system parameters and providing complete facilities for plant operation and optimization.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system. For each abnormal condition, Plant failure, Plant unavailable or failure to respond to a command within a given period, the system shall provide the appropriate alarm.

Printed and archived alarms shall be time and date stamped for occurrence and acceptance. Alarms, logs and reports shall be output to separate printers. Alarms shall be in red. The ability to generate alarms within the system software based upon digital and / or analogue events and set points shall be provided.

An alarm horn with silence button shall be provided to alert the operator of an alarm condition. Specific alarm, monitoring and control input / output requirements shall be determined from the particular control specifications and the Project Drawings.

SCADA Software & Hardware Minimum Requirements:

General:

- 1) The Contractor shall be responsible for supplying complete software packages to enable the equipment to operate as stated in this specification. Provision must be made for the adding of further software tasks as and when required. All software functions shall be user friendly, with instruction and messages to aid the operator. The Contractor shall make available all standard software functions, even if not specifically detailed in the specification.
- 2) The computers shall utilize a real time multi-tasking and networked operating system with a proven track record in real time control applications.
- 3) SCADA Server stations shall be with 32" LED monitor system, loaded with latest authorised windows 2019 server operating system, latest MS Office professional ,licensed latest & proven PLC programming software ,licensed SCADA software, centralized server monitored Anti virus software, required licensed network monitoring software,licensed firewall software, etc... with all accessories complete
- 4) CCTV stations with 32" LED monitor systems, loaded with latest authorised windows operating system, latest MS Office professional ,licensed CCTV software, licensed client Antivirus software ,required licensed network monitoring software, etc.. all accessories complete suitable for interconnection with external networks in a Wide Area Network (WAN) configuration, where specified.

- 5)** Online printers (A3 Size all in one printer), inclusive of printer servers with all accessories complete to meet the requirements.
- 6)** The Application Software shall provide communication with other industrial standard open networks. The Software shall support Object Linked Embedding for Process Control (OPC).OPC shall be a in-built feature of the software.
- 7)** The System shall support a fully distributed 64 bit Client/Server architecture. The System shall include Visual Basic for Applications (VBA) as a built-in programming language. Facility shall be available for building custom objects using VBA. Object oriented graphics and tools to easily build reusable control strategies. ODBC Application Program Interface (API) capable of collecting and writing secure real-time electronic records to one or more relational database.
- 8)** The software shall support OPC standards as both a client and a server for fast and reliable communications with a wide variety of hardware devices. Provide Active-X controls with selection of third-party Active-X controls for ready-made solutions without VBA programming. The SCADA software shall use SQL server as the integral database.
- 9)** A standard software package, such as Crystal Report shall be provided to facilitate generation of free format, intuitive and presentation quality reports.
- 10)** The Server shall provide the master clock for the SCADA time synchronization.
- 11)** SCADA design shall include de-activation of CTRL+ALT_DEL windows feature. The same shall be demonstrated during FAT.
- 12)** The SCADA system shall be designed to be initialized without any operator intervention/windows login: the SCADA software and all other associated software (inclusive of windows software) shall be loaded and the main screen shall be displayed for the plant operator to enter the login credentials, without any operator intervention to meet the criteria. The same shall be demonstrated during FAT.
- 13)** The system software shall be from the SCADA manufacturer as indicated in the approved vendor list elsewhere in this specification. Third party software is not acceptable. It is a requirement that the system be supported by on line configuration and editing of all VDU mimic displays and database and to create new displays and additional database.
- 14)** Both PLC hardware and SCADA software shall be from single OEM.
- 15)** Operational mimics and other graphics shall be presented in an industry standard graphical user interface (GUI) format. A minimum of two active windows shall be displayable concurrently and not more than three windows. Both text and graphics shall resize automatically to accommodate changes made to the size of a window. The system shall be designed to minimize the operator's use of the keyboard. All major functions shall be accessible on-screen through use of the mouse.
- 16)** SCADA shall be designed to disable right click options (from the mouse or trackball) to provide greater security to the system and to prevent un-authorised modifications to the system by the plant operator. The same shall be demonstrated during FAT. The operator login shall not be allowed to view or modify any other function, command depending on the level of authority of the operator.

- 17)** Operator system entry, for each area will be password coded with different levels of entry depending on the level of authority of the operator. Development and systems level entry passwords will be provided for engineering workstations. Each action taken by any operator at any level of entry, or at any operator terminal, shall be log file recorded and time and date stamped. Log in and out time and dates will be printed on the control room event logging printer.
- 18)** Right click menu options on SCADA software shall be designed to be disabled.
- 19)** All requests and commands shall be via icons, whether menu linked or linked to equipment control actions. A permanent dynamic alarm banner shall be displayed at the bottom or top of each operator screen. Each control action will be routed through a series of confirmation routines.
- 20)** The reports shall be available for printing in graph or tabular format. Dynamic trend displays shall also be available for all analogue flow, level and pressure values. Custom, as well as preconfigured reports and trends shall be available to a higher level of entry. A colour, A3 size, multi-function printer shall be provided for graph and trend prints.
- 21)** An operator help utility shall be provided, offering help linked to the particular action being carried out by the operator at that time. At least one help screen per screen page shall be available. This facility shall be preconfigured with an option for updating by operators, via a password entry.
- 22)** The Application Server software shall be configurable to provide for the monitoring and control of all points, loops, and systems through graphic display screens and hard copy reports. These shall include:
- Parameter Displays for signal control
 - Control Loop Status Displays
 - Real Time and Historical Data Trend Displays
 - Event Displays and Log Reports
 - Alarm Displays and Log Reports
 - Equipment Diagnostic Displays and Reports.
- 23)** The system shall provide on-line diagnostics that display the current status and operation of the local area network and its nodes. The diagnostic display shall include the LAN adapter status for the machine showing the display, as well as the current number of messages, errors and retries.
- 24)** The system shall conform to and take advantage of industry standards. These shall include, but not be limited to:
- ODBC
 - OLE
 - ActiveX
 - COM/DCOM
 - DDE and Advance DDE
 - C programming language
 - Visual Basic
 - Microsoft Windows XP or the most current Operating System

- TCP/IP
- OPC
- XML

- 25)** Display Facilities and screen/mimic refresh: The displays shall be user configurable, with the user being able to construct any desired symbol for display. Any display shall appear (excluding historical recall) within 1 seconds to 2 seconds of selection and the displayed data shall be updated from the database .Alarms shall typically appear within 3 seconds to 5 seconds of occurrence and within 1 second of being received into the central system database. Plant mimics shall display dynamic color details of flow rates and pressures, pump status, well levels, alarms, electrical power supplies and other general equipment status conditions. The plants mimics shall include animation to depict complete plant process operation, pump running station, media flow within the plant, levels in the tank, etc. The animation shall be designed such that the screen refresh rate shall not effected. and shall be maintained within 4.16 msecs. The refresh rates shall be 240Hz.The SCADA servers and workstations, monitors (engineering & operator) shall be suitably chosen to meet this requirement.
- 26)** The Contractor shall configure all display pages as fully as possible. However, facility must be incorporated to permit easy construction and modification of the display pages, by using a standard library of shapes and symbols. The library shall be added to and modified by the user as required. The configuration shall be object orientated for ease of use.
- 27)** The initial application software shall provide for the display pages listed below and any pages necessary for the system to function as a complete entity.
- a)** Mimic displays
 - b)** Graphic displays.
 - c)** Trend displays.
 - d)** Alarm summary tables with date and time.
 - e)** Event logs of past 72 hours with date and time.
 - f)** Tabular display of data.
 - g)** Inset windows showing an analogue trends may be mixed with mimic displays.
In such a display the main mimic and inset trend shall all be live with automatic display updates.
 - h)** Indexing of information and menus shall be presented in the form of active windows on the screen, while the mimics etc. are still available for view.
 - i)** No display or function shall effect the logging/monitoring of data. It shall be possible for the master station terminal and auxiliary terminals to perform simultaneously, different tasks within the display.
- Monitoring and Alarms

- 1) The operator shall be able to monitor all of the information at the workstation. He shall be able to view active equipment information by use of graphical and tabular displays.
- 2) In the event of an equipment alarm, the following shall occur at the master station:
 - a) Alarm message displayed in the alarm message area of the screen.
 - b) The audible alarm shall sound.
 - c) The appropriate Section of the display page shall change color and flash.
 - d) A full message shall be written on the alarm page.
 - e) The full alarm message shall be printed on the alarm printer.
 - f) The full alarm message shall be recorded, stored on disk and automatically archived.
- 3) The operator shall be able to acknowledge the alarm by pressing an accept alarm key or icon. This action shall stop flashing of all associated alarm messages and displays. However the display shall remain in the alarm state fixed color to indicate an accepted alarm. When all outstanding alarms have been acknowledged the audible alarm shall be silenced.
- 4) Once the alarm has cleared, the messages and displays shall return to normal. The alarm message shall stay recorded on the event/alarm log and an alarm cleared message shall also be recorded.
- 5) If the alarm clears before being acknowledged the sequence of events shall continue as above except the message shall change to indicate a cleared alarm.
- 6) An audible alarm silence function shall be provided to enable an operator to silence the audible alarm without acknowledging all alarms. On occurrence of any subsequent alarm, the audible alarm shall sound.
- 7) Each signal within the configured system shall be capable of being assigned an alarm based on the following:
 - a) Four levels per analogue (Lo Lo, Hi Hi, Lo and Hi).
 - b) Rate of change.
 - c) Deviation from set point or other control parameter.
- 8) Alarms shall be time tagged to 1 second resolution at the I/O's.
- 9) A minimum of four alarm priorities shall be provided so that those requiring immediate attention may be separated from alarms of lower priority. An audible alarm shall sound for alarms requiring operator action.
- 10) Typical alarm assignments are as follows:
 - a) critical alarm - an alarm that requires immediate operator action
 - b) non critical alarm - an alarm that requires operator action but not necessarily immediate action
 - c) operator guide alarm - an alarm that provides information to the operator

d) event - a low priority condition which is recorded.

Data Archiving

Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable media system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes for a period of three months locally. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 60% full.

Analogue will be stored at a rate selected by the operator in the range 1 second to 1 hour. The operator shall have the facility to select the way in which an analogue is stored.

The system will provide any combination of the following:

- Instantaneous value.
- Average value.
- Maximum value.
- Minimum value.
- Not stored.

Maximum, minimum and average values shall be calculated over a period set by the operator in the range 15 minutes to 24 hours, the default shall be 1 hour.

The logging of new data and reception of alarms must be carried out at the same time as the operator is viewing archived data. Any alarms received must be displayed as an overlay on the visual display unit.

The contractor shall submit the data archiving policy to be adopted as part of functional design specifications for review and approval. The same shall be demonstrated during the factory acceptance test and site acceptance test.

SCADA Screens/Mimics

The Contractor shall configure all the mimics to provide total detailed coverage of the monitoring and control of equipment as detailed in this specification. It is expected that display modifications will be required in the future and therefore the ability to change the displays without programming skills is essential.

The plants mimics shall include dynamic animation to depict complete plant process operation, pump running station, media flow within the plant, levels in the tank, etc. The animation shall be designed such that the screen refresh rate shall not be effected and shall be maintained within 4.16 msec at all times. The refresh rates shall be 240Hz. The SCADA servers and workstations , monitors (engineering & operator) shall be suitably chosen to meet this requirement.

Instrumentation shall be displayed using ISO standard symbols. For mimic configuration, it shall be possible to call up a library of standard symbols representing items (e.g. pumps, valves) and add new symbols to the library. Building mimics shall be simple and be achieved by using a mouse or tracker ball pointing device.

The mimic displays shall consist of the following pages on a minimum but not limited to:

- a) A general diagram covering the entire plant, any associated systems on a single screen with key data being displayed. The same shall be constituted as plant

overview screen. The same shall be programmed with complete animation to depict the normal process operation and process media flow within the plant system.

- b) A general block diagram for each site or area of Site showing the equipment displayed on a series of single screens with key data
- c) Mimic of the equipment and instrumentation connected to each IO module displayed on as many screens as necessary.
- d) Individual process screens
- e) PLC network monitoring screen
- f) Communication interface with PS control system and other interfaces as required under this contract.
- g) Individual vendor packaged PLC monitoring screen
- h) Login screens, reports screen, security screen, overall PS screen, etc. Shall be configured.
- i) Screens indicating the current status of each equipment, maintenance schedule/status, Run hours, set points for all equipment inclusive of vendor supplied systems
- j) Complete operational screens shall be developed for plant SCADA for vendor packaged system irrespective of the vendor system HMI screen supplied.
- k) Fire alarm system monitoring screen inclusive of all I/O points in the network

The SCADA software shall have the ability to limit the number of displays being opened simultaneously at any given point of time. The software shall be able to display at least three individual process screens/pop up screens simultaneously and shall be active screens. The contractor during detailed design shall ensure that no two windows/pop up screens of same process shall be opened simultaneously. The above feature shall be displayed during FAT.

20.24.1 Trend Displays

It shall be possible to plot dynamically updated real time data and archived data on a line graph, to represent analogue or digital information. Each graph shall be capable of displaying 8 plots overlaid on a graph of different colors and line texture. Next to the graph, there shall be a key relating each color to its function.

The horizontal axis shall be time based and user selectable in minutes, hours, days, weeks, for example, together with a start time.

The vertical axis shall be scaled as a percentage of range and be displayed in the colour of the selected reading. To avoid cluttering, the vertical axis scale shall be changed by selecting the individual display. The vertical axis shall be automatically scaled for each selected point, between limits entered by the user.

Actual values in engineering units shall be displayed by positioning a cursor at the desired point of the trend graph. The display of the data shall also be available in tabular form.

a) Manual Data Entry:

The system shall be provided with facility for entering data manually via the keyboard. This data will fall into two types:

- a)** Constants which will be changed infrequently. This data may have time and date associated with it.
- b)** Maintenance related comments.

b) Manually Corrected Data:

The system shall allow a person with authorized access to correct manually, erroneous data via the keyboard.

20.24.2 Reports

There shall be a real time spreadsheet facility supplied and installed by the Contractor. The users shall be able to transfer data from either the archive system or live data to the spreadsheet.

The user shall be able to produce daily, weekly, monthly and annual reports using any data and a mixture of formats (tables, graphs, summaries, spreadsheets). It shall be possible to generate reports, either automatically at predetermined intervals, or manually on demand by the Operator.

Typical reports on a minimum to be provided but not limited to:

- Flow
- Process parameters
- Pump performance monitoring from the vendor system
- Failures of equipment.
- Clear Water Reservoir levels.
- Discharge pressures.
- Maintenance schedules.
- Power consumption for all equipment
- Process alarm conditions.
- Communication interfaces report between each integrated link/site.
- Status of vendor control packages

20.24.3 Profiling

From an average, typical or manually entered plot, it shall be possible to set an exception profile whereby readings within an upper and lower level are acceptable. Profiles shall be set graphically via OW.

The user may select for the system to alarm if the reading is outside the profile and highlight such exceptions as part of a report, thereby reducing the need to examine all data, to ensure acceptability. The number of exceptions shall be logged.

20.24.4 Data Manipulation:

It shall be possible to perform simple mathematical functions on any data, including the following functions:

- Addition
- Subtraction
- Multiplication
- Division
- Square root

It shall be possible to log, display or use in a control loop, the resultant data.

20.24.5 Database Query Facilities:

The system shall support the use of database relationships and wild card characters to provide database query facilities. It shall be possible for applications integration to configure queries easily and save them for future use.

Support of Dynamic Data Exchange (DDE) or Structured Query Language (SQL), to permit data exchange between the SCADA and external applications, including spread sheets and databases.

Data shall be presented in tabular format and contain any combination of fields from the main system database. It shall be possible to manipulate the data by specifying search and sort criteria to define data range limits.

Once a query table has been created, it shall be possible to store the configuration and initiate successive look-ups, using a point and shoot technique.

20.24.6 Downloading IO Configuration:

It shall be possible to download configuration to the IO's from the engineering work station and the Portable Programming Unit (Laptop).The same shall be demonstrated during FAT.

20.24.7 Diagnostics:

The system shall have on-line diagnostic facilities to report system faults as they occur. A set of off-line diagnostic routines shall be supplied for more extensive fault diagnosis. The same shall be demonstrated during FAT.

20.24.8 Security Access Levels:

The functions available on the system shall be fully flexible so as to allow users access levels to be customized by the system operator, to suit individual user requirements.

Access to management and engineer levels shall be restricted by user selectable passwords or key switch. The security systems shall be based on a set of privileges, which may be granted or denied to individual uses by the system operator.

Windows functionality of CNTRL+ALT+DEL shall be disabled. On SCADA startup, the system shall load and directly enter in the SCADA welcome home page .The design shall ensure that SCADA software development page shall not be accessed during the startup and only on appropriate login access, the same shall be accessible. The same shall be demonstrated during SCADA FAT .

The security/access levels would be divided between Engineers, supervisors and operators.

The system shall be protected from un-authorized changes to the operating system and application programs.

The system shall prevent un-authorized users from re-booting the system or aborting or suspending system-related programs.

The system shall provide three levels of operator access to the system as a minimum, with the first level permitting access to viewing selected plant conditions as described below and the highest level intended for the system manager.

A mechanism shall be provided which prevents users operating at a lower level from accessing functions assigned to a higher level.

The system shall provide a password-protected, user log-on facility for definition of the user access level.

Passwords entered during the log-on process shall not be printed or displayed.

The software shall monitor the actions of the user currently logged on at each node and shall log the current user off after a definable extended period of no operator interaction with the system and produce a printed log-off message.

Logging off of the user shall not shut down the system or the SCADA mimic shall not log out. When the operator has logged off, the current SCADA mimic shall be visible for monitoring, but no action shall be possible until the operator has logged in back to the system.

System-generated log messages relating to operator actions, such as alarm acknowledgements or set-point changes, shall include the identification of the current logged-on user.

The Contractor shall provide the following defined user access levels as a minimum and additional levels as instructed by the Employer Representative:

1) Default Level:

The default level shall permit users to view all displays except those specifically assigned to a higher level of access.

2) Operator level:

The operator level shall permit authorized users to access default level activities in addition to the following:

- a) Perform control actions;
- b) Acknowledge alarms;
- c) Enter or modify manually entered data for inclusion into reports.

3) System manager level:

The system manager level shall permit authorised users to access default level and operator level activities in addition to the following:

- a) Modify alarm and control set points, dead bands and time delays;

- b) Enter or modify historical data;
- c) Add, delete or modify individual I/O points or point attributes;
- d) Add, delete or modify field device configurations;
- e) Create, delete or modify control algorithms;
- f) Create, delete or modify graphic displays;
- g) Create, delete or modify system reports;
- h) Configure trend displays;
- i) Access the operating system;
- j) Assign access levels and user passwords;
- k) Perform any other system maintenance function

20.24.9 Programming:

The method of programming will depend upon the Manufacturers system requirements. However, the following standards shall be followed:

- a) All programs shall be written such that they lend themselves easily to alterations and additions.
- b) Good programming practice shall be followed using structured programming techniques. All programs shall be tidy in format and logical to follow. Programs shall be extensively annotated with comments and be self-documenting.
- c) The system shall be supplied with programs that use a high level language.

20.24.10 Programme – Documentation:

As part of the requirements of this specification full documentation is required as below on a minimum:

- a) Software user manuals
- b) Database point allocation table
- c) Complete program listing, flow charts for all sequences and control routines
- d) Application software source code(applicable even for packaged control systems)
- e) End user license agreements.

20.24.11 Control Room Furniture

In addition to the SCADA system equipment, the Contractor shall provide industrial grade system consoles to complement or match both the colour and styling of the equipment. The Control room

Furniture shall comply with relevant IEC standards for ergonomic design. System console shall be so designed to house all servers, workstations. Monitors, interface equipment with cables having back entry. Details and design of system consoles shall be submitted to the Engineer for review and approval.

Additionally, the Contractor shall provide five ergonomically designed swivel-type adjustable arm chairs with casters, two lockable cupboard with glass doors , three lockable File cabinets to store reports, storage of operating and maintenance manuals, drawings, logger paper, charts, disks and the like. Air conditioning for the complete control room shall be provided. The Calculations for the air conditioning systems keeping in view of the heat dissipation shall be submitted for review and approval.

20.24.12 Mandatory Spares for PLC & SCADA to be supplied and to be demonstrated during FAT

Contractor shall provide all the services and supplies in accordance with approved procedures for handling of spare parts, which shall include arranging for their proper receipt, stacking and storage.

Contractor shall identify, define, procure, and supply construction, pre-commissioning, commissioning and start-up spares, special tools and handling gear for each item of equipment.

On a minimum, 1PLC CPU, 2 DI Module, 2 DO Module, 2 AI Module, 1 Nos of GPRS communication module, 1 no of managed Ethernet switches of each type installed , 2 Nos of PLC and RTU batteries,30% fuses of each type and size installed shall be supplied and shall be demonstrated during FAT of the control system)

The same shall be demonstrated during FAT and before commencement of SAT.

20.24.13SCADA Hardware

The system shall support hardware and software interconnectivity to other networks generally in accordance with the ISO Open System Interconnect 7 layer reference model.

20.24.14Computers (Workstations):

- 1) The computer hardware shall be of current technology at the time of installation. Standard server stations, with modern hardware, latest Windows operating system and data transmission over Industrial Ethernet must be used for the workstations. It must be possible to install more than one engineering station in a system. Minimum 2 Tb capacity systems shall be supplied. The workstation & monitor shall support minimum screen refresh rate shall be maintained within 4.16 milli secs. The refresh rates shall be 240Hz.The SCADA servers and workstations, monitors shall be suitably chosen to meet this requirement. All hardware shall be of reputed make. All softwares alongwith operating system eg. Windows, Microsoft office, SCADA HMI etc. shall be latest and of paid licenced version. Paid licenced anti-virus software package of reputed make shall be installed on the workstations.
- 2) The engineering system must be an open system that, for example, permits the importing of project data from Microsoft Excel, SQL or from CAD/CAE programs. It must be possible to import/export messages to/from Excel and Access for simple processing. Removable memory media must also be provided for each workstation.

It must be possible to back up all database and configuration data both on removable media and on non-removable storage media without the system being offline.

Provision of redundant storage media must be possible for the configuration database. The specs for computer hardware shown are indicative only and minimum requirement to be supplied by the contractor.

- 3) SCADA servers shall be based on latest windows servers operating system
- 4) All workstations, servers, communications equipment and peripherals shall be from reputed manufacturers, suitable for continuous operation and shall be the most currently available models at the time of construction, subject to approval. Adequate spare capacity shall be included to meet the specified requirements and future expansions. On a minimum, all servers & workstations shall not be loaded more than 60% of their capacity. An alarm shall be generated when this capacity is exceeded. The above feature shall be demonstrated during FAT.
- 5) The system shall support hardware and software interconnectivity to external Programmable Logic Controllers (PLC's) over an RS-232/RS-485 serial data link

using Profibus / Modbus, Ethernet or similar protocol, subject to the approval of the Employer Representative.

Workstations:

Processor	Intel Xeon E3-1220 3.10 GHz v2
RAM	6GB (1 X 6GB) Non-ECC configurable Up to 32 GB 1600 MHz DDR3
Storage	2TB SATA HDD
ODD	DVDRW
Graphics	NVIDIA Quadro 2000 1Gb graphics with Dual Display Port, Dual-link DVI and supporting maximum resolution of 2560x1600
Monitor	32" LED Monitor Multiple input .options – DisplayPort, DVI-D and V, Wide viewing angle with native resolution of 1680 x 1050; 16:10 Aspect ratio; 5ms response time ,ENERGY STAR 5.1 compliant, TCO certified Edge 1.1, and Mercury/Arsenic free glass ,screen refresh rate: 240Hz
Ports	(4) USB 3.0 (Rear);(2) USB 2.0 (Front)
Ethernet	Gigabit ethernet
OS	64-bit Latest OS professional version (Minimum)
Warranty	Three-year(Extendable to 7-years),next business day warranty including labor and parts, 24x7support

Remote telemetry Unit (RTU):

Specification	Requirement
Dynamic memory (RAM)(program execution, dynamic variables and file system, etc.)	Min 32 Megabytes or more
Program memory (Flash)(for	Min 64 Megabytes or more

Data-log memory (RAM) (for data log and retained variables)	Battery-backed – Rechargeable Lithium. The contractor shall provide in his offer, the selection and sizing calculations with reference to the RTU regarding sufficiency of Memory and Processing power of RTU to handle all the specified functions, storage requirements, data-up date speeds, etc. shall be taken care of in the selection and sizing.
Battery-backup time and	1yearbackup time and battery life of 10+years
Real-time clock resolution	10Ms
Real-time clock accuracy	+/-15 seconds per month
Data log modes	Trending, alarm log, sequence of events, event initiated, client transfers, and others
IEC	Yes
Language support	At least two or more from Ladder logic, function chart, function block, instruction list, structured text, and flowchart
Cycle time	10 ms minimum (user settable)
Communication capabilities	Master, slave, peer to peer, report on exception
Communication	Ethernet(TCP/IP)andRS485(MODBUS)
Telemetry(built-in)	Built-in GPRS (with4G and compatible with 5G); Incase 5G is unavailable at this point of time, it shall be compatible to 5G in future with minimal downtime to the system operations and no extra cost to END USER.
CPU watchdog	CPU automatically resets if error is detected; status LED flashes error code
Ethernet Port	Networkport:1 shielded RJ45connector with Isolation to1.5kVrms/ 1minute Message response time (typical) – 5ms Diagnostic LEDs–(speed and activity) Protocols supported–TCP/IP,ARP, UDP, ICMP,DHCP, Modbus/TCP

Serial Ports	Minimum two numbers RS232 Port RJ45/DB9, atleast one RS485 Port with Screw termination (support for full-duplex and/or 2-wire half-duplex) Protocols – MODBUS ,Software, RTS-party (for radios and RS-485)
Discrete Inputs	No. of channels :As per requirement +30% spares ,with ON Voltage 9 to 30VDC, OFF Voltage 0 to 5VDC Input Resistance: 10K Ohms, Input Current @ 24V / 3 Ma
Discrete Outputs	No. of channels: As per requirement +30% spares (10-30VDC) with Maximum Output per channel of 1amp Typical ON resistance:0.3ohms and Typical ON voltage (@1A) – 0.3VDC
Analog Inputs	No. of channels; As per requirement +30% spares A/D resolution – 16bits (0.003%),Full scale accuracy-+/-0.1% (@20deg.C) Input impedance – 100 Ohm, Differential mode rejection 66Db at 50/60Hz
Input voltage	10to30VDC (integrated switching supply)
Temperature	-40 to 70°C (-40 to 85°C storage)
Humidity	5% to 95% RH (non-condensing)
Mounting	DIN rail

HMI / PANELPC

Specification	Requirement
Front Bezel:	Aluminum w/IP65/NEMA4ruggedprotection
LCD Panel:	Display size 16" colour touch screen or greater LCD .
	Brightness 350nits
	Resolution 1280 x 1024 pixels
	Viewing Angle80°/80°
	Display Size:16" minimum
	CPU LGA1155 socket 3 &2 nd GenerationIntel®Core™i7/i5processor

Main System:	System Memory 2 x 204-pin DDR3 SO-DIMM max.upto 16GB Storage 2 x 2.5" SATA HDD Drive1 x built-in slim DVD-RW(optional) Watchdog Timer 255 levels,1~255sec.
Operating System:	Latest Windows .(Contractor shall submit compliance test report w.r.t various applications, functionality)
IO Connector:	3 x RS-232 (COM2-4) 1 x RS-232/422/485 (COM 1) 1 x RS-232 with 5V & 12V (COM 3) 1 xDVI-D 1 xVGA 6 x USB 2.0(back) 2 x USB 2.0(front) 2 x 10/100/1000 Mbps Ethernet 1 x Audio (Mic-in/Line-out)
Touch screen:	5-wire resistive type 1millionactivations(typical) at a single point
Power Supply:	100 ~ 240VAC,270W
Dimensions:	469 mm (W) x 94.7 mm (D) x 380.8 mm(H)
Environment:	Operating Temperature: 0° ~ +45°C (+32°F ~+113°F) Storage Temperature: -20°C ~ +65°C (-4°F ~+149°F) Relative humidity:10~95%@40°C,non-considering Operating vibration: 1.0G, 5-500Hz,random
Processing and Memory	The contractor shall provide in his offer, the selection and sizing calculations with reference to the HMI regarding sufficiency of Memory and Processing power of HMI to handle all the specified functions, storage requirements, data-update speeds, etc. shall be taken care of in the selection and sizing.

DC Power Supplies

Specification	Requirement
Nominal input	230VAC
Frequency	47 Hz to 63Hz
Input current	3.2 A typ. At 230VAC
Mains failure	> 20 ms at 230VAC
Nominal	24VDC
Output current	10 A at 24VDC
Adjustment	1%
Degree of protection	IP20
Operational indication	LED green(24VDCo.k.),LED red(overload)
Type of mounting	DIN-rail mounting(DINEN50022)
Ambient	-10 °C to +70°C
Wire	Cage Clamp
Type	SMPS, shielded metal case, with provision for earth

Intrinsic Safety Barriers

Specification	Requirement
Channels	Isolation type IS Barriers, DIN Rail mount
Type	DC version, positive polarity
Nominal	300Ω
Fuse rating	50Ma
Working	Max. 27 V , 26.5 V at 10 μA
Degree of protection	IEC60529
Ambient temperature	-20 ... 60 °C (-4 ... 140°F)
Storage temperature	-25 ... 70 °C (-13 ... 158 °F)
Degree of protection	IP20
Mounting	Standard 35mm DIN mounting rail (EN60715:2001)

Group, category, type of protection, temperature class	II3GExNaIICt4Gc[device in zone 2]
Directive94/9/ EC	EN 60079-0:2009, EN 60079-11:2007, EN 61241-11:2006 , EN 60079-15:2010
IEC Ex approval	IEC Ex BAS09.0142

Surge Protection Barrier

Specification	Requirement
Channels	1-Channel
Rated voltage Un	$\leq 30V$
Rated current In	$\leq 250mA$
Leakage current	$\leq 5\mu A$
On-state voltage	$\leq 45V$
Nominal discharge current(8/20)In	10kA per core,5kA per core(10x)
Max. surge	20kA per core,10kA per core(1x)
Degree of protection	IEC60529
Ambient temperature	-30...80°C(-22...176°F)
Degree of protection	IP20
Mounting	DIN rail mount module
Group, category, type of protection, temperature class	Ex II 2(1)G Ex ia IICt6
Directive94/9/EC	EN60079-0:2006,EN60079-11:2007
IEC Ex approval	IECEx BAS14.0010X

ROUTER for 4G

Specification	Requirement
Important 4G features	<ul style="list-style-type: none"> • Auto-switch fail over between primary and backup link • Multichannel-interface-processor (MIP) profile configuration • Remotely initiated data callback using voice • Remotely initiated data call back using Short Message Service (SMS) • Remote firmware upgrade over 4G • Virtual diagnostic monitoring • Mobile Equipment Personalization (MEP) lock and unlock capabilities • SIM lock and unlock capabilities
Dual SIM support	<ul style="list-style-type: none"> • High reliability and cellular multi-homing support for HSPA and HSPA+ based networks • Dual SIM card socket; compliant with ISO-7816-2 (SIM mechanical) • Two Internal SIM Card Slots:
SMS	<ul style="list-style-type: none"> • Ability to send and receive SMS (maximum of 160 characters)
3G/4G network management and diagnostics	<ul style="list-style-type: none"> • In-band and out-of-band management using Telnet (Cisco IOS Software command-line interface [CLI]) and • Industry-standard 4G diagnostics and monitoring tools (QUALCOMM CDMA Air Interface Tester [CAIT] and Spirent Universal Diagnostic Monitor [UDM])
Included antenna	Two multiband swivel-mount dipole antennae (4G) and one extender (4G-AE010-R) to be included Routers.
	<ul style="list-style-type: none"> • Received signal strength indication (RSSI) (green) • WLAN

LED indicators	<ul style="list-style-type: none">• WWAN• SIM status• 3G/4G service (green/amber)• SYS• ACT
IP and IP services features	<ul style="list-style-type: none">• Routing Information Protocol Versions 1 and 2 (RIPv1 and RIPv2)• Generic routing encapsulation (GRE) and multipoint GRE (MGRE)• Standard 802.1d Spanning Tree Protocol• Layer 2 Tunneling Protocol (L2TP)• Layer 2 Tunneling Protocol Version 3 (L2TPv3)• Network Address Translation• Dynamic Host Configuration Protocol (DHCP) server, relay, and client• Dynamic Domain Name System (DNS)• DNS Proxy• DNS Spoofing• Access control lists (ACLs)• Ipv4 and Ipv6 Multicast• Open Shortest Path First (OSPF)• Border Gateway Protocol (BGP)• Performance Routing (PfR)• Enhanced Interior Gateway Routing Protocol (EIGRP)• Virtual Route Forwarding (VRF) Lite• Next Hop Resolution Protocol (NHRP)

	<ul style="list-style-type: none">• Bidirectional Forwarding Detection (BFD)• Web Cache Communication Protocol (WCCP)
Switch features	<ul style="list-style-type: none">• Auto Media Device In/Media Device Cross Over (MDI-MDX)• 8 802.1Q VLANs• MAC filtering• Switched Port Analyzer (SPAN)• Storm control• Smart ports• Secure MAC address• Internet Group Management Protocol Version 3 (IGMPv3) snooping• 802.1x
Security features	<ul style="list-style-type: none">• Secure Sockets Layer (SSL) VPN for secure remote access• Hardware-accelerated DES, 3DES, AES 128, AES 192, and AES 256• Public-key-infrastructure (PKI) support• 20 Ipsec tunnels• Dynamic Multipoint VPN (DMVPN)• Tunnel-less Group Encrypted Transport VPN• Ipsec stateful failover• VRF-aware Ipsec• Ip sec over Ipv6• Adaptive control technology• Session Initiation Protocol (SIP) application layer gateway• Zone-Based Policy Firewall• Stateful inspection transparent firewall

	<ul style="list-style-type: none"> • Secure HTTP (HTTPS), FTP, and Telnet Authentication Proxy • Dynamic and static port security • Firewall stateful failover; VRF- aware firewall <p>Content filtering:</p> <ul style="list-style-type: none"> • Cisco IOS Software black and white lists <p>Integrated threat control:</p> <ul style="list-style-type: none"> • Intrusion prevention system (IPS) • Control Plane Policing • Flexible Packet Matching • Hierarchical QoS (HqoS)
Ipv6features	<ul style="list-style-type: none"> • Ipv6 addressing architecture • Ipv6 name resolution • Ipv6 statistics • Ipv6 translation: Transport packets between Ipv6-only and Ipv4-only endpoints (NAT-PT) • Internet Control Message Protocol Version 6 (ICMPv6) • IPv6 DHCP
Memory	
DRAM	At least 512MB
Flash memory	At least 256MB
Interface Support:	
Console or auxiliary port	RJ-45: Single dual-purpose port, which provides direct connection to a console or external modem for management or backup access point
Mini-USB port(RSVD)	Mini-USB port to support remote 3G diagnostics and monitoring tools (QUALCOMM CAIT and Spirent UDM)

WAN interfaces	<ul style="list-style-type: none">• Wireless WAN with 3G, 3.5G and 3.7G speeds
	<ul style="list-style-type: none">• 10/100/1000 Giga bit Ethernet port
LAN interfaces	<ul style="list-style-type: none">• Four 10/100 Fast Ethernet ports
Standard safety certifications	<ul style="list-style-type: none">• UL 60950-1, 2nd edition

20.24.15 Broadband Internet

Broadband internet services with high speed connectivity shall be supplied for connectivity with centralized SCADA center and for web connectivity. The most suitable package of broadband internet service provided by an Internet Service Provider (ISP) which suits the Client's requirement shall be utilized. The contractor shall enter into SLA agreement to provide continuous fail safe services as required under this contract.

20.24.16 Fixed Line

For locations where ISP is readily available, the technology which supports the broadband services shall be based on Digital Subscriber Line (DSL). The type of DSL utilized shall be of the Asymmetrical Digital Subscriber Line (ADSL) which shall allow simultaneous access to the net and usage of the telephone or fax line. Certified ADSL modems shall be utilized. Splitter and micro filter shall be installed on the telephone or fax line to avoid interference.

20.24.17 Monitor

- 1) Visual Display Units (VDU's)/Monitor shall be color monitor screens with required monitor stand to support dual functionality, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats. 2 in 1 dual monitors shall simultaneously display a minimum of 256 colors, non-interlaced, low radiation, flat screen with no discernible flicker. Display of characters shall be legible and stable on a shadow mask tube, having a resolution of not less, so that 1024 by 768 pixels and a refresh rate of not less than 240 Hz. The units shall include all the necessary picture controls to adjust the sharpness, contrast and position of the image. LED VDUs shall be flat screen, minimum requirements: brightness 250 cd/m², 500:1 contrast ratio, 1600 x 1200 pixels.
- 2) VDU's shall be 32 inch LED Screens on a minimum.
- 3) VDU's shall be fitted with a power management system to reduce consumption upon detection of a stand-by signal from the PC.
- 4) Note: Each SCADA server, CCTV workstation, CCTV system shall be provided with VDU units as described above.

20.24.18Printer

Colour Multifunction Printer:

Color Multifunction printer shall be used for the production of color screen dumps and reports and shall have a sufficiently sized buffer memory such that system performance will not be degraded when the color printer is operational and comply with the following:

Printer Specification:

All-in-one functions	Print, copy, scan, fax, standalone scan-to email, photo card slots
Multitasking capability	Yes.
Paper Size	A3,A4
Print speed, black (normal quality mode)	Up to 21 ppm
Print speed, color (normal quality mode)	Up to 21 ppm
Print speed footnote	Exact speed varies depending on the system configuration, software program, and document complexity.
First page out (color)	As fast as 17.9 sec
Monthly duty cycle	Up to 40,000 pages
Footnote for duty cycle	Duty cycle is defined as the maximum number of pages per month of imaged output. This value provides a comparison of product robustness in relation to other LaserJet or Color LaserJet devices, and enables appropriate deployment of printers and MFPs to satisfy the demands of connected individuals or groups.
	Paper Heading:
Paper handling standard input	50 sheet multi-purpose tray 1, 250-sheet input trays 2 and 3, 50-sheet ADF
Paper handling standard output	150-sheet face-down output bin
Envelope capacity	Up to 30 envelopes
Envelope feeder	No
Duplex printing (printing on both sides of paper)	Automatic (standard)
Document finishing	Sheetfed
Media sizes, standard	Letter, legal, executive, envelopes (No. 10, Monarch)
Media sizes, custom	Tray 1: 3 x 5 to 8.5 x 14 in; Tray 2, Tray 3: 3.94 x 5.83 to 8.5 x 14 in
Media types	Paper (bond, brochure, colored, glossy, letterhead, photo, plain, preprinted, prepunched, recycled, rough), transparencies, labels, envelopes
Media weight	Tray 1: 16 to 47 lb (up to 58 lb with Color Laser glossy photo papers); tray 2, tray 3: 16 to 43 lb (up to 47 lb

	with postcards, up to 58 lb with Color Laser glossy photo papers)
Weight	71.2 lb
Processor speed	450 MHz
Memory, standard	160 MB
Memory, maximum	416 MB
	Scanner Specification:
Scanner type	Flatbed, ADF
Scan resolution, optical	Up to 1200 dpi
Bit depth	42-bit
Scan size, maximum (flatbed)	8.5 x 11.7 in
Scan size, maximum (ADF)	8.5 x 14 in
Scan speed (default)	Up to 15 ppm
Automatic paper sensor	No
	Copier Specification:
Copy speed (black, best quality, A4)	Up to 20 cpm
Copy speed black (best, letter)	Up to 20 cpm
Copy speed color (best, letter)	Up to 20 cpm
Copy resolution, black	Up to 600 x 600 dpi
Copy resolution, color	Up to 600 x 600 dpi
Copy reduce/enlarge settings	25 to 400%
Maximum number of copies	Up to 99 copies
	Fax Specification:
Faxing	Yes
Fax transmission speed (seconds per page)	3 sec per page
Fax memory	Up to 250 pages
Fax note	Based on standard ITU-T test image #1 at standard resolution. More complicated pages or higher resolution will take longer and use more memory.
Fax resolution, black (dots per inch)	Up to 203 x 196 dpi
Speed dials, maximum number	Up to 120 numbers
Auto redial	Yes
Fax delayed sending	Yes
Fax broadcast	119
Junk fax barrier	Yes
Polling	Yes (receive only)

Remote retrieval	No
Fax forwarding	Yes

20.24.19 Uninterruptible Power Supply (UPS) for complete Instrumentation, Control & Automation

The UPS shall be floor mounted; self-contained and metal clad and shall be suitable for supplying a non-linear load. It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact to touch.

The UPS shall be an on-line type incorporating a six pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch which shall operate in the event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply.

The UPS shall incorporate a dc under voltage trip circuit to electronically trip the UPS output in order to protect the batteries.

The noise level of the unit shall not exceed 60dB(A) at 1 mtr from the UPS cabinet.

The output of the inverter shall be a sine wave having less than 2% THD for linear loads and less than 4% for 50% non-linear load. It shall be suitable for load power factors 0.7 lag to 0.9 lead.

The unit shall have a dynamic response such that a 100% step load causes an output voltage transient of less than $\pm 4\%$ with a recovery time of less than 4 ms.

For three phase output units the output voltage shall not vary by more than $\pm 1\%$ for an unbalance of 10%.

The load crest factor shall not be less than 3:1.

The efficiency at full load and 0.8 power factor shall be greater than 88%.

The UPS System shall communicate the following status data to the plant SCADA system to monitor: (Note: To be demonstrated during FAT)

- UPS status
- UPS alarm conditions
- Battery capacity
- Bypass status
- Fault

The UPS shall provide a volt free contact output to indicate:

- warning, i.e. low battery capacity
- fault
- static bypass in use.

The UPS shall have an overload capacity of 150% for 30 seconds and shall be protected in the event of a short circuit of the output.

The batteries shall be housed, either within the UPS enclosure or within a separate matching battery cubicle suitable for location adjacent to the UPS. The UPS battery shall be located in a well ventilated area.

Technical Particulars:

Each UPS shall have the following features:

- a) The UPS shall be stand alone, true on line, based on advanced IGBT PWM technology with microprocessor based control, monitoring and fault diagnostics, static by pass switch and front access oriented layout.
- b) Main Parameters:

1	Input Voltage	415V +10% -15 % A.C. Three phase 4 wires with Solidly earthed Neutral.
2	Symmetrical Short circuit level. Frequency	25kA 50Hz ± 5%
3	Output Voltage	240 ± 1% A.C, Three Phase 4 wire with Solidly Earthed Neutral.
4	Frequency Wave form	50Hz ± 5% True Sine Wave
5	Isolation	True on line with complete galvanic Isolation
6	Total harmonic Distribution	< 2% for linear load, < 3% for non-linear load
7	Over load Capacity	125% for 10min 150% for 10Sec
8	Transient Response	Remain within ± 1% and recover to 100% within ¼ Cycle
9	Crest factor	3 : 1
10	Duty	Continuous
11	Static by pass	to be provided
12	Efficiency Converter Inverter Overall	> 94% > 93% > 87%
13	Max Ambient Temp and Relative Humidity	45°C & 100%
14	Cooling	Forced air
15	Acoustic Noise Level	<60db at 1.5m
16	Battery backup	60min for full load.

- c) The UPS shall be complete with Isolation transformer, Converter cum Changer, inverter, protections, indications, programming, microprocessor based monitoring and fault diagnostic system, communication facilities, redundant control power supplies, SMF battery, accessories and interconnecting Cables.
- d) Constructional Features: The UPS shall be high quality CRCA sheet steel enclosed suitable for floor mounting. The sheet steel shall be of 2mm thick. All sheet parts shall undergo phosphating process to ensure anti rust conditioning and superior finish. Premier quality powder coating shall be applied. The degree of protection

shall be IP 54. The UPS panel shall be provided with two earthing terminals. The final finish shall be Light Grey Semi Glossy Shade 631 of IS 5.

Converter cum Charger:

When normal AC supply is available, DC power for the inverter is fully supplied by the converter and the battery is kept under float charge. On main supply failure, the battery shall be automatically connected to the Inverter without interrupting the output voltage for critical load. Similarly on normalization of AC power, the DC load shall be transferred to the converter and battery shall be put on float charge without interruption at output side. The converter cum charger shall be designed to deliver the full load DC required by the inverter and charging of the battery. Battery charging shall be with float & boost mode selection with current limit.

1) Inverter:

The static inverter shall convert the power from the converter/battery into stable AC power which is supplied to load. The inverter shall be with the latest IGBT PWM technology with specially designed output transformer.

2) Battery Bank:

Batteries shall be 12V, SMF (sealed maintenance free) type. The Qty & AH of batteries shall be suitable for backup period of 60 minutes for full load.

The battery shall be rated to provide full load power for required backup time on AC power failure. After delivering this amount of power, the battery shall be suitable for recharging through converter cum charger on AC power restoration. The battery shall be mounted on a separate rack. The battery bank shall be complete with battery stand, interlinks and UPS to battery interconnecting cable. The battery bank shall be installed in a separate room with good ventilation in the administration building.

3) Other features:

The other features of UPS shall be as follows:

- i)** Microprocessor based Control, monitoring and fault diagnostics.
- ii)** Comprehensive LED mimic and LED display with keypad Control to enable the following:
 - a)** Date-time stamped event recording and logging in a non-volatile memory
 - b)** Programming and Monitoring of various system parameters
 - c)** Status indications and number of LCD digital meters.
- iii)** 100% Nonlinear local handling Capability with low distortion of less than 5% and high crest factor of 3:1
- iv)** RS 232c/ RS 485 interface port.
- v)** Front access layout.
- vi)** Inbuilt line chokes for main power supply.
- vii)** Indications:
 - Mains 'ON'
 - Converter 'ON'
 - Inverter 'ON'
 - Battery Low

- Over load
- Inverter Trip
- Charger Trip
- Output 'ON'

viii) Protections:

- Incomer MCCB with Overload & Short circuit releases
- Outgoing MCCB with Overload & Short circuit releases
- Battery MCCB with Overload & Short circuit releases
- Input under/over voltage
- Converter over voltage
- Battery Low
- Battery charging current limit
- Output under voltage
- Output over voltage
- Output over load
- Output short circuit
- Inverter over temp
- Single phase prevention

Alarm and trip conditions shall be separately enunciated.

The backup period shall be minimum 2 hr on full load.

Testing Requirements

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following on a minimum:

- change-over from full load with mains present to full load on battery supply;
- carry out a discharge test on the system at full load and for the specified duty bridging time period;
- carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.
- Demonstrate the full functioning of the PLC& SCADA system while running on UPS power.
- All Routine/acceptance tests as per relevant Indian / International standards shall be carried out in the presence of Employer / his Employer Representative

Quality Assurance/Quality Control (QA/QC):

QA/QVC shall comply with the Contract, with particular requirements specific to the equipment or service being provided as outlined below for PLC & SCADA systems and other equipment that shall comprise the instrumentation and automation system under this contract. The quality assurance/control procedures shall include, but not be limited to the following:

- Continuity and Wiring tests;
- Insulation and High Potential Testing;

- Complete functional test inclusive of data interfacing with third party system for monitoring;
- Packaging and Shipping;
- Welding;
- Cleaning and Painting.

The quality assurance/quality control documentation shall include, but not be limited to the following:

- Material Certifications;
- Shop Test Reports;
- All other documentation required by applicable codes and standards.

20.24.20SCADA Control Room design

General Design Considerations

An ergonomic approach to the design of centralized SCADA monitoring center workstations and the layout of the control room shall contribute to achieving safety and performance objectives set for the centralized SCADA room.

Effective control room design shall consider safety and performance / aesthetic objectives and function to create workspaces that facilitate the complex interaction between operators, technology and the environment. Raised flooring, acoustic concerns, indirect lighting and the wellbeing, health and safety of each operator shall need to be addressed.

Operators in the control room shall work 24 hours a day, 7 days a week.

Control room design shall take into consideration room size, number of operators, viewing requirements and equipment. Operators shall be able to communicate with each other as well as have easy access to essential equipment. The height of the console shall be calculated so the shortest operator can see over the top of any workstation mounted electronics to remote monitor walls, control panels or displays and the clearance underneath the work surface should allow for the tallest operator to sit comfortably.

The contractor shall design the control room based on international accepted standards taking care of the aesthetics and operator comfort and plant view. The Control room aesthetics design shall be submitted for review and approval before any design of the control room is taken up.

When designing the control room to address these and other concerns, the following steps shall be taken to ensure operator comfort and minimize fatigue:

- Test console layout with operators for “human tasks” including sequential task simulations.
- Develop workstation layouts designed around acceptable reach zones and visual limitations.
- Take into account maintenance requirements and removal of equipment from both the rear and front of the workstation.
- Provide ergonomic footrests where appropriate.
- Provide 24/7 chairs with full adjustment capabilities.
- Reduce excess heat and noise by locating electronics in an equipment room.

- In workstation dimensions, consider the full height and size range of the operators, utilizing height adjustable work surfaces where appropriate.

The SCADA control room shall be constructed to a high standard to provide a high profile feature and focal point for visitors to the PS.T he contractor shall design the control room based on international accepted standards taking care of the aesthetics and operator comfort and plant view. The Control room aesthetics design shall be submitted for review and approval before any design of the control room is taken up.

SCADA control room and associated areas shall be equipped with false flooring & false ceiling. The entire control room and associated areas shall be provided with air-conditioning systems (at least four nos of 2 tonne air conditioners in the main control room & server area).

SCADA control room shall be designed to have maximum view of the plant and plant operation. The brick masonry works in the control room shall be replaced with full length glazed windows with access control system and CCTV system to prevent un-authorised access .No UPS system shall be installed in the control room. A separate UPS room with battery room shall be provided in the administration building for the purpose.

The SCADA control room shall be equipped with false flooring to provide access for all cables. No cables shall be installed over the control room floor.

The SCADA control room shall be provided with air conditioning system .The temperature in any area of the control room shall not exceed 22deg C

The SCADA control room shall be equipped with Fire alarm, suppression and detection system.

1. Electrical & Earthing Requirements for SCADA control Room

SCADA Control room Power distribution system shall have redundancy at two levels. The electrical system shall be designed to incorporate spare capacity (Minimum 20%) at each distribution level. All wiring up to the SCADA Control room shall be laid in powder coated MS conduits / Aluminium raceway.

All power cables up to the SCADA Control room shall be PVC insulated type. All cables shall be armoured cable type except where flexibility required does not permit use of armoured cable.

Earthing system shall be as per IS – 3043.

Contractor shall design and implement anti- static EMI / RFI protection arrangement, wherever necessary.

The contractor shall design, engineer, supply/manufacture, test, erect, install, connect; commission and site test the Electrical Distribution System for any and all power requirements within the SCADA Control room facility. This shall include, but not be limited to UPS, Lighting system, ACDB system and input power to various sub systems of the Server/SCADA Control room like cooling units, alarm systems etc.

Design, engineering, supply, section, wiring, commissioning and testing of all systems are in the contractor scope. Contractor shall design, engineer, supply, commission and test the electrical system considering the various loads it has to cater to.

The technical specifications and the scope for various items provided herein need to be verified by the Contractor. Contractor's scope shall include end to end system that is designed and implemented according to various applicable standards / regulations and meets total requirement for the Server/SCADA Control room Facility.

Copper earth pit station as per IS - 3043 using 600 X 600 X 3 mm copper earth plate complete with accessories and hinged cover shall be provided by the Contractor. Another earthing system shall be extended for equipment body earthing of SCADA control room, using 25 X 3 mm GI strip. Two Earthing pits shall be provided for UPS Earthing, which will be interconnected, and same grid will join the building-earthing grid at only one point. Earthing System shall be designed & maintained considering personnel safety and noise-resistant electronic environments by providing equi-potential bonding with earth resistance of less than 3 ohm. Contractor shall design, supply and implement the most efficient and safe earthing system considering the types of load, fault conditions, cross current circulation, spikes, circulating current due to potential differences, etc.

The earthing system implemented shall ensure safety of people and systems under all conditions. Earth fault protection shall be designed and implemented by the Contractor for all loads

2. Fire Alarm System

The contractor scope of work shall include on a minimum, design, engineering, supply and installation & commissioning of Fire Alarm System suitable for control room and all ancillary facilities area.

Fire Alarm System (FAS) shall be designed to detect & suppress the incipient fires and generates audio/ visual alarms in case of fire. The system shall consist of automatic fire detectors and manual call point & break glass units. Automatic fire detector shall work on principle of sensing the smoke, heat or infrared rays.

Detector shall be provided in control room and various location in the administration building. Manual call point shall be provided at exit doors/ routes of control room. Number of detectors and manual call point shall be decided as per guideline and codes.

Fire alarm system shall be microprocessor based fire alarm system and shall have addressable type field devices. It shall comprise following equipment's used in conjunction with addressable automatic detectors & and addressable MCPs.

1. Multi loop Data Gathering Fire Alarm Panel (DGFAPs).
2. Sirens & Starters, Hooters, exit signs.
3. Interface with other systems thru Dual redundant data highway with complete network hardware.

System shall be modular and facilitate future extension up to 20%. Redundancy shall be provided at Processor, communication, power supply level. Fire alarm logic shall be programmable type. Minimum number of detectors/ MCPs/ addressable devices in single loop shall be 60 nos. Conductor size of loop cable shall be 1.5 sq. mm copper. All field devices like detectors, MCP shall be addressable type. Fire alarm system shall be interfaced with Fire extinguishing system.

4. False flooring:

Finished height of Access floor up to 450mm Raised flooring shall be provided.

- a. The raised floor must be capable of withstanding a uniform load of 1,220 kg/m² with a maximum deflection of 2.5 mm.
- b. The recommended panel size for the raised floor is 610 mm square. These panels must be easily removable to facilitate access to the under-floor area. Special weather coating on back side of the tiles to be provided.
- c. The raised floor must be level within +3.2 mm overall and within +1.6 mm in any 3.05 m (10 ft) distance.
- d. Fire resistance of floor material must comply with more stringent, local regulations. It should be totally fire proof.
- e. The metallic structure of the raised floor must be electrically bonded to the ground to minimize static buildup. The floor panels must have conductive contact with either the framing, the pedestals, or both for positive electrical grounding.
- f. Panel surfaces must be high-pressure laminate. Do not use carpeting. Use material that is both dust and crack resistant. The material must withstand movement of heavy equipment on casters and must resist the buildup of static electricity. Cleaning products containing ammonia must not be used.
- g. All cable openings in floor panels must have plastic edging to prevent damage to cables
- h. Provide adequate drainage to ensure that no moisture accumulates in the recessed area

Following provisions for the computer system between the raised floor and the primary floor: shall be provided:

- AC power distribution for the computer system
- Input/output cables.
- Air ducts or passages for cooling air
- Cable ducts

Clearance between the raised floor and the primary floor is 450 mm.

- i. The cables are to be routed along the under floor and brought up to the cabinet locations prior to placing the cabinets.
- j. Ensure that at least 102 mm (4 in.) of free space exists between the top of the under-floor cables and the raised floor. Route the cables so that excessive buildup does not occur in any local area. Cables routed under the floor that are to connect to electronic equipment must be routed so that excessive strain does not occur on the connector due to inadequate space for bent radius of the cable. In the case of the large diameter input/output cables for peripheral equipment, provide a minimum bend radius of 212 mm (6 in.). All cables are to be routed at 90 degree angles. Power and signal cables must be separated by 150 to 300 mm to minimize noise interference.
- k. Matching/approved profiles to be provided

20.24.21 Inspection & Testing Requirements:

A. Inspection and Testing Requirements for Instrumentation works

a) Inspection, Testing and Setting to Work — General

Each item of plant shall be subjected to the manufacturer's own tests which shall be certified. Each item of plant and its installation shall be subject to inspection and testing at the place of manufacture. The Contractor shall be responsible for the provision of all necessary test equipment. The Contractor shall demonstrate to the Engineer, the correct operation of any item of plant and the Engineer may witness any test. Tests which, in the opinion of the Engineer, were failed or not performed correctly shall be repeated.

Before any test is made, the Contractor shall submit to the Engineer a full list of test equipment to be used. Each item of test equipment shall have a standard of accuracy better than that stated by the manufacturer of the item to be tested. The Contractor shall provide evidence of the condition and performance of any item of test equipment, in the form of test certificates issued by an appropriate authority independent of the Contractor and manufacturer, or as otherwise directed by the Engineer. Test equipment shall be checked frequently during the period of the tests.

The Contractor's staff responsible for supervising and carrying out tests shall be fully conversant with the various items of equipment of other manufacturers and if necessary the Contractor shall arrange for his personnel to attend suitable training courses on his own expense. The contractor has to get approval from the client's representative for the training personnel to be employed by the contractor.

Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Engineer before proceeding with further inspection or testing of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

b) Preliminary Inspection and Testing at the Place of Manufacture

Field Instruments

After the successful completion of the manufacturer's own inspection and testing of instruments to be supplied under the Contract, similar tests shall be carried out in the presence of the Engineer, engineer's representative and the Contractor at the manufacturer's factory where the instruments have been manufactured. No deviation on the same shall be acceptable. Such tests shall include a demonstration that an increase or decrease of the measured value at several points over the full range of the instrument produces a corresponding increase or decrease in the instrument output signal. These tests shall include checks on the specified accuracy of the instrument at all points. Complete functional testing of all instruments (Field instrumentation inclusive of pump performance monitoring system)

c) Instrument panels, enclosures and mounting boards

The manufacturer shall not present instrument panels, enclosures, junction boxes and mounting boards (assemblies) for inspection and testing until the manufacturer's own tests and inspection has been completed. A preliminary inspection and test of these assemblies may then be witnessed by the Engineer, engineer's representative. The Contractor shall give not less than 7 days' notice in writing that he has completed his tests and inspection and is ready for the witnessed tests and inspection. Where this notice period is different in the Conditions of Contract this shall take precedent.

The witnessed inspection and testing shall include the following on a minimum:

- a) Complete functional testing of the instrument inclusive of calibration and sampling system (applicable for all field and analytical instruments);
- b) A visual inspection of the panel assembly to show that the design, construction and finish are satisfactory and in accordance with the Specification;
- c) A check that equipment is securely mounted, accessible for removal or calibration without damage to or undue disturbance of other components, wiring or piping;
- d) That all engraving and labels are correctly positioned, fixed and designated in accordance with the Specification;
- e) Panel power-distribution circuits have the correct breaker/fuse rating coordination and designation;
- f) Power-isolation facilities meet the Specification;
- g) The main incoming supply voltage, frequency and/or pneumatic supply pressure is within the required limits, these being checked at the beginning and end of the test and the results recorded on test certificates;
- h) The output of all power supply units again at the beginning and end of the testing with results being recorded;
- i) The power supply voltage or air pressure of all component instruments of the assembly(s), these voltages/pressures being recorded on the test certificate;
- j) The insulation resistance of all circuits except sensitive electronic equipment which is liable to damage by application of the test voltage, such circuits being disconnected before making the insulation resistance tests and these tests being carried out in accordance with IEE Wiring Regulations;
- k) That the clean earth bar is isolated from main frame of the panel. Internal lighting and anti-condensation heaters and associated thermostats, isolators, limit switches and wiring shall be checked for compliance with the Specification. Spare capacity within the panel(s) shall be checked to see that it complies with the Specification. This shall include future equipment space, spare terminals, space in wiring trunking and provision for additional cable entry

d) Functional Testing at the Place of Manufacture

General requirements

Once the preliminary inspection and testing is complete to the satisfaction of the Engineer, functional testing shall commence in the presence of the employer and employer's representative for 100% quantity of all equipment. The purpose of the functional tests are to demonstrate that all instruments and pump performance monitoring system instruments, panels' enclosures and mounting boards (assemblies), sampling system conform to requirements of the Specification. Functional testing on a minimum shall include, calibration check as per established international standards, transmitter function check, error reporting, alarm functions, communication check with external third party devices, etc.

Not less than 30 days before the commencement of functional tests, the Contractor shall submit to the Engineer, for approval, two copies of comprehensive test procedural documents detailing each test to be carried out. The document shall include results forms on which the results of each test will be entered. The forms shall include spaces for numerical values, where necessary, and witness signatures. All applicable drawings and data shall be provided at the place of inspection by the Contractor.

The Contractor shall provide all test instruments and equipment necessary to test the assemblies in their entirety.

The following is a typical list of the equipment required:

- Switch boxes;
- Indicator light boxes;
- Analogue signal sources;
- Dummy loads;
- Meters;
- Simulators;
- Desk-top computers;
- Programmers for PLC or outstations;
- Insulation test equipment.

e) Quality Assurance/Quality Control (QA/QC)

QA/QC shall comply with the Contract, with particular requirements specific to the equipment or service being provided as outlined below for ICA systems. The quality assurance/control procedures shall include, but not be limited to the following:

- Continuity and Wiring tests;
- Calibration check;
- complete functional testing of equipment along with sampling system(as applicable);
- Insulation and High Potential Testing;
- Packaging and Shipping;
- Welding;
- Cleaning and Painting.

The quality assurance/quality control documentation shall include, but not be limited to the following:

- Material Certifications;
- Shop Test Reports;
- All other documentation required by applicable codes and standards.

B. Inspection and Testing Requirements for Control & Automation works

a) Factory Acceptance Test (FAT)

The Contractor shall conduct a full programme of tests of the PLC & SCADA system at the manufacturer /system integrator testing facility in the presence of the Engineer to verify that all features of the system have been provided, are operating correctly and are in full compliance with the Specification. Unless otherwise specified or agreed by the Engineer, the entire PLC & SCADA system shall be assembled and tested together as an integrated system, including all master station equipment, all operators' consoles, all outstations and telemetry equipment all instrumentation panels and uninterruptible power supplies included in this Specification. The scheduled date for the factory acceptance test shall be as agreed by the Contractor and the Engineer at least four weeks before the test.

Not less than one month before the scheduled factory acceptance test, the Contractor shall submit to the Engineer for approval two copies of a comprehensive manual detailing each test to be conducted. The manual shall include a results form on which the results of each test will be entered, including spaces for numerical values where appropriate and witness signatures.

Not less than 7 days before the scheduled factory acceptance test, the Contractor shall give written notification to the Engineer that a complete dry-run of the factory acceptance test has been performed successfully and that, in the opinion of the Contractor, the system exhibits stable operation and is ready for the formal factory acceptance test.

The factory acceptance test will be considered successfully completed only when the system has successfully passed all factory tests. The system shall not be delivered to Site until the successful completion of the factory acceptance test is certified by the Engineer or unless otherwise approved by the Engineer. Delay in the delivery of the system due to failure of the factory acceptance test shall not constitute an unavoidable delay. If the system fails the factory acceptance test, the test shall be extended or rescheduled at the discretion of the Engineer.

All hardware to be used in the testing of the system shall have passed an agreed preliminary hardware performance test to ensure known hardware operability before software testing begins.

After successful completion of the factory acceptance test, no software changes shall be made to the system without written authorisation by the Engineer. Any changes to the system which effect the system software documentation, such as input scale modifications or changes to the control logic, shall be entered into the system documentation before delivery of the system to Site.

The entire cost of the complete FAT and any other required testing(interoperability, site visits etc..), including reasonable per diem expenses to cover meals, lodging, transport and similar expenses for all end user & employers representative personnel attending the tests, shall be the responsibility of the Contractor/ system supplier and shall be included in the contract price.

b) Factory Acceptance Test Procedures

1) General

The scope of the tests shall include the proving of every aspect of hardware and software operation and functions as detailed below.

2) Hardware tests

- (a) Verify the correct inventory of hardware including cables and printed circuit boards;
- (b) Demonstrate that all spare-memory, disk-capacity and system-expansion requirements have been met;
- (c) Demonstrate all hardware and software diagnostics;
- (d) Verify all power supply voltages are within tolerance;
- (e) Verify proper earth connections and isolation of instrumentation earth for all equipment;
- (f) Demonstrate operation of test simulation and indication equipment and its Suitability for adequate functional testing of all system functions.

3) Software tests

- (a) Demonstrate the editing of all system parameters including set-points, timers and the like;
- (b) Demonstrate system configuration capabilities including the addition and deletion of input and output points, outstations, and all data base parameters.
- (c) Demonstrate the addition, deletion and modification of mimic displays and report formats;

4) Functional tests

The functional tests shall verify proper operation of every specified system function as an integrated system. These tests shall be conducted in conjunction with functional tests of instrumentation and control panels as specified elsewhere. All failures or discrepancies found shall be documented in the test manual.

Following a failure of any functional test, should software or hardware modifications be required it shall be the decision of the Engineer whether the factory acceptance test is to continue, re-start or be aborted. If testing is allowed to continue, any changes which are required shall be described in a system modification document, signed by both Contractor and Engineer and be incorporated into the final factory acceptance test documentation. The failed test shall be re-conducted and the Engineer may require the retest of functions which may be affected by the modification.

The functional tests shall include, as a minimum, the following:

- (a) Demonstration that the system meets the requirements of the Specification for response time and speed of screen update
- (b) Verification of the accuracy of all analogue input points in the system. The procedure shall include applying the appropriate signal to each analogue input at a minimum of three points within the range of the input, checking for expected numerical results, and verifying appropriate update of related mimic displays. Proper sensing and action by the system to high and low out-of-range inputs shall also be verified
- (c) Verification of the proper logic sense, pulse accumulation and rate computation where appropriate, of all digital inputs and verifying appropriate update of related mimic displays;
- (e) Verification of all control and sequencing operations and proper operation of all digital and analogue outputs. The procedure shall include simulation of all related process variables for both normal and abnormal conditions, including instrument and component failure, and demonstration of fail-safe response of the system. System outputs shall be indicated with appropriate lamps and indicators;
- (f) Simulation of outstation communications errors and failures and demonstration of error detection and handling, failure detection and handling, and appropriate changes to control actions as designed and specified;
- (g) Verification of fault detection and diagnostics by inducing a sufficient variety of fault conditions in the system to ensure that detection processes and fail-safe operation are adequately tested;
- (h) Demonstration of proper operation of all mimic displays, help pages, reports, operator procedures and historical data accumulation;
- (j) Demonstration of proper operation of all outstations following a simulated master station central processor failure;
- (k) Demonstration of proper operation of all equipment during both a system wide or isolated power failure, and following power restoration. The procedure shall include the demonstration of battery backup of both master station and outstation for the full length of

time specified, and proper operation of power fail, low voltage warning and all associated alarms.

5) Reliability test

After successful completion of the functional tests a 48-hour continuous run of the system shall be performed. The test shall be passed if no system function is lost or no hardware or software failure occurs. Hardware failure is defined for this test as the loss of a major component such as the computer, an outstation, a VDU or a peripheral device. Non-repetitive mechanical failures of loggers, push-buttons and the like are excluded.

During this test, the system shall be exercised with simulated inputs and conditions in a manner which approximates the on-site operational environment. Unstructured testing by the Engineer shall be included during this test. Upon any system failure during this period, it shall be the decision of the Engineer whether the reliability test is to continue or be aborted. If testing is allowed to continue any changes to the system which are required shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final factory acceptance test documentation.

c) Factory acceptance test documentation

As a minimum, the following information shall be included in the factory Acceptance test manual for each test:

- Test identification number;
- Test name and description;
- List of all equipment to be tested including any special test equipment required;
- Description of the test procedure broken down into logical steps;
- Description of the expected system response verifying the completion of each logical step;
- Space for recording the results of the test and the time and date of the test;
- Space for signatures of the Contractor and the Engineer.

In addition, the Contractor shall provide a method for recording and tracing all problems, discrepancies, queries and suggestions regarding the system and software, and for formalised control of any modifications to the system.

d) Pre-commissioning tests

The Contractor shall perform pre-commissioning, or preliminary, testing of the SCADA system in accordance with that specified for instrumentation. The purpose of pre-commissioning tests is to confirm readiness of the system for commissioning.

The scope of pre-commissioning tests shall be generally as specified for factory acceptance tests but real field inputs and final control elements shall be used wherever practical to provide inputs to the system and to confirm proper outputs.

Where this is impractical, simulation signals shall be injected as near as possible to their ultimate sources so as to include in the tests as much of the cabling system as possible.

Each process system shall be set to work under manual control and the system tested to confirm proper operation. After proper operation of manual control mode has been verified, tests of automatic controls of each process system shall be conducted wherever practical.

e) Site Acceptance Tests (SAT)

The Contractor shall submit all relevant draft operating manuals for the PLC & SCADA System to the Engineer for approval prior to commissioning tests. Any faults or failures of the system detected during the previous tests shall be noted and corrected to the satisfaction of the Engineer before commissioning is allowed to commence.

As part of commissioning, control and instrumentation system (the PLC & SCADA system, and the entire communication system) shall be tested for availability for a continuous period of fifteen days. The control and instrumentation system shall be subjected to SAT only after the complete plant electro-mechanical and ICA works have been completed and tested to perform as per contract requirements and both manual and auto mode of operations has been completely tested and found to be as per contract requirements. During this period, the system will perform the normal functions according to the procedures described in the SAT documentation approved by the Engineer.

The system shall have passed the SAT if all major components have been free from fault or failure and exhibit full error-free functionality for 100 % of the total duration of the test, unless otherwise agreed by the Engineer. Major components include all master station equipment, outstations, communications facilities and instrument panel components, excluding push-buttons, switches and lamps and any equipment not supplied by the Contractor.

During SAT, no modifications to the system shall be made by the Contractor without the written approval of the Engineer. Erroneous functioning which requires software modifications or re-configuration to correct, other than set-point or parameter changes, shall constitute a failure of the availability test. Any changes to the system which are required and approved shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final test documentation. The test shall be restarted after corrections have been made.

20.24.22 Training Requirements for Instrumentation, control and Automation works

A. After Conduction of Site Acceptance Test(SAT)

Training shall be provided for ten (10) of the END USER personnel at the PS facility on operations and maintenance of all system components. The training program shall be divided into two segments and shall consist of at least two (2) working days, each of 8 (eight) hours duration. This shall include (Field instrumentation, CCTV systems, Fire Alarm system, Process equipment suppliers (vendor supplied systems), Plant operations, Control & Automation systems, etc.

The maintenance training program shall be developed for personnel that have electronics maintenance and repair experience and a general knowledge of computer systems, but shall not assume any familiarity with the specific hardware furnished.

As a minimum, the following subjects shall be covered:

- System Architecture and Layout
- Hardware Components

- Module Switch Settings (Configuration Switches)
- I/O Modules
- Power Supplies
- Data Highway:
- Programmer connection
- IOP programming and diagnostic techniques
- Battery replacement and recharging
- PC and workstation familiarization and maintenance:
- Troubleshooting
- Disassembly
- Cleaning
- Component Replacement
- Re-assembly
- The operation training programme shall include the following topics:
- Power-up, bootstrapping and shutdown of all hardware devices
- Interpretation of all standard displays
- Appropriate actions for software and hardware error occurrences
- Use of operator interface displays and keyboards
- Use of printer including replenishment of supplies
- Manual data entries
- Creation and editing of graphic operator display screens.
- Loading of any required software into the system
- Data base creation and editing.

Section 2E

Operation and Maintenance

Section 2E – Comprehensive Operation & Maintenance

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1. General

This section covers activities involved in Operation and Maintenance of the Storm Water Pumping Station at Mogra, Mumbai and the taking over of the installation by the owner.

2. Operation & Maintenance

2.1 Scope of work

The contractor is to Operate and Maintain entire Storm Water Pumping Station facility for a period of seven years as Part B of the Contract, after successful completion of Part A of the Contract described in Section 2A, Volume 2 of this tender document, during both monsoon period and non-monsoon period. During Operation and Maintenance of the Storm Water Pumping Station in each monsoon and non-monsoon period, the Contractor shall monitor and record the performance of Pumps and DG sets as well as that of all individual equipment and accessories installed and operated in the storm water pumping station. Various components of storm water pumping station which will be operated and maintained by the contractor for a period of seven years shall include all the components i.e. Civil structures, Waterways, Buildings and overall pumping station premises, Mechanical equipment and accessories, Electrical – Instrumentation equipment and accessories of the Storm Water Pumping Station described elsewhere in this document but not limited to the following:-

- Regular cleaning and desilting of such portion of nalla on the upstream side of screens, Mitre Gates, portion between screens and mitre gates and on the downstream side of Mitre Gates for which nalla training or nalla deepening or nalla retaining wall construction has been carried out by the Contractor in part "A" of this contract.
- Regular desilting and cleaning of downstream of nallah shall be carried out to ensure that mitre gates can be smoothly operated during low / high tides throughout the year
- Removal / shifting of sand dunes, if any, shall be carried out before onset of monsoon every year
- Complete desilting of the silt pit shall be carried out before monsoon each year
- Mitre Gates / roller gates, Stop logs and Mitre Gate / roller gate structure, downstream area of Mitre gate / roller gate
- Screens and Stop logs
- Trash racks
- Screen structure
- Mechanical Screen Cleaning arrangement
- EOT Crane for Mitre gates

- EOT Crane for grab bucket
- Main Submersible pumps with submersible motors
- Removal, Collection and disposal arrangement for Deposits, debris, silt, suspended and floating matter, Screenings etc. from Silt trap in front of Screen, Screens face, and Mitre gate area
- D.G. platform
- Diesel engine driven Main and Auxiliary Power Generating sets, control panels and related instrumentation, DG chimneys, Hot air exhaust etc.
- Main Electrical panel room, PLC-SCADA room and operations room
- All HT and LT Electrical panels, Soft starters, Auto synchronization panels, NGR and NIS panels, APFC panels, Transformer, related instrumentation,
- PLC-SCADA system complete including local control panels, level sensors, transmitters, relays, UPS system etc.
- Internal and external sewage network including accessories, Internal and external water supply network including accessories, water tanks and pumps
- Fuel transfer systems including fuel transfer system for DG sets complete including Bulk Diesel storage tanks, Day tanks and Pumps, related instrumentation
- Equipment and panel base frames including foundations
- Entire Pumping station premises including roads, pathways, gangways, boundary wall, entry-exit gates, gratings, hand-railings, platforms, internal and external lighting including lighting fixtures, ACDBs and street poles, safety grills / barbed wire fencing, room air conditioners and room ventilation, garden, maintenance platforms, approach ladders, safety ladders etc.
- Entire internal and external HT, LT and Control cable network including cables, cable trays, cable trenches, conduits etc.
- All internal, external and area lighting including streetlights, fans, exhaust fans
- Office Furniture and office accessories, air conditioners, doors, windows, ventilators,
- All toilets, toiletries, sanitary wear and accessories installed in toilets,
- High pressure jet cleaning system
- Forced air ventilation system
- Dewatering pumps
- Firefighting system complete, Safety equipment complete
- Earthing system, Lightning protection system,

- Painting / of equipment, Structures, mounting frames, Hand railings, rolling shutters, Grills etc.

All the consumables including diesel used for power generation, grease, lubricants, paint, construction materials, spares required for operating and maintaining the Storm Water Pumping Station during Operation and Maintenance period shall be supplied by the contractor. Also other consumables such as office consumables and office stationery, toilet accessories and toiletries, consumables for area cleaning, sweeping and maintaining hygiene inside the entire plant premises, gardening consumables and accessories, water supply and sewerage shall also be provided by the Contractor. All these provisions will have to be made by the Contractor during tenure of the Contract at his own cost and no separate payments will be made to the Contractor on these accounts. All charges towards usage of electricity, water, communication (telephones, internet etc.), property taxes, deployment of skilled manpower / specialist etc. shall also be borne by the Contractor.

The contractor shall provide a full-fledged service set up within 100km from Mumbai.

The contractor shall ensure proper running of the plant to give the desired performance. The contractor shall also be responsible for overall maintenance of the plant i.e. civil, electrical, mechanical, instrumentation installations including pumps and D.G. sets. The contractor shall also be responsible for all repairs of equipment/machinery including replacement of damaged / defective parts or equipment as a whole.

The Contractor shall also be responsible for cleaning debris, floating / suspended materials, silt, deposits etc. in the Inlet bay area on a regular basis to ensure smooth passage of incoming water towards and through the screen. The screens shall also be cleaned on regular basis mechanically or manually to prevent blockage of screens especially during pumping operation.

It shall be the responsibility of the Contractor to collect and remove screenings including debris, deposits, silt, suspended / floating material, rags, tree branches, dead animal bodies and other screenings and to ensure that removed screenings are disposed off as per MCGM's debris management plan including transporting to the specified location or dumping ground within municipal limits as directed by Engineer. No separate payments will be made to the Contractor for these works.

The scope shall also include cleaning of areas in front of and behind the screens, trash racks, pumps at regular intervals with help of pressurised water jets whenever required thereby ensuring that these areas are kept free from deposits, debris, silt etc. The Contractor shall also be responsible for keeping the dredged areas on the downstream of Mitre gates and Outlet bay free from deposits / obstructions.

The contractor shall monitor the operation and maintenance of the plant and equipment and maintain all the records in SCADA system. The contractor shall take necessary actions to ensure smooth and satisfactory performance/running of the plant.

The contractor shall prepare and implement an effective plant maintenance programme in consultation with Engineer. It shall be absolutely contractor's responsibility to look after all sorts of maintenance whether preventive or break down. The contractor shall maintain the operational activity record as per standard practise in the formats approved by Engineer in SCADA system.

The contractor shall be responsible to carry out day to day as well as periodic maintenance necessary to ensure smooth and efficient performance/running of all equipment/instruments installed plant.

The entire pumping station and premises shall be maintained in hygienic and pleasant manner by carrying out required cleaning and periodic repairs for all the structures, internal roads, Water Supply, Drainage, Firefighting, Electrical systems, etc. within Pumping Station premises. The approach road, street lighting and storm water drains shall be maintained as per MCGM specifications during the entire O&M period. The required repairs shall be carried out promptly by the contractor. On failure, the Engineer-in-charge shall give a written notice to the contractor. If the contractor fails to comply or make good the defects the Engineer-in-charge may carry out the work at risk and cost of the contractor and such failure will be considered as non-performance on the Contractors part.

After successful completion of Operation and Maintenance period, the contractor shall hand over entire Storm Water Pumping Station Facilities including all Civil, Mechanical and Instrumentation works in good running condition to the entire satisfaction of the Engineer. Tests if any demanded by the Engineer to establish good running condition of the Storm Water Pumping Station shall also be carried out by the Contractor without any extra cost to the satisfaction of the Engineer. Only after fulfilling all above requirements, the Engineer will issue certificate of successful completion of Part B of the Contract and the Storm Water Pumping Station facility shall be taken over by MCGM.

The contractor shall be responsible for keeping updated record of data collected and generated including History-Card for each equipment and maintaining every day logbook relating to running of machinery, consumption of energy, fuel, lubricants and other consumables during the entire period of operation and maintenance in the SCADA system. The data recorded in SCADA system to cover following minimum information:-

- i. Daily status record of all equipment
- ii. Daily operational log of Main submersible pumps and D.G. sets including log of all other mechanical, electrical and instrumentation equipment and accessories installed and operated in the Storm Water Pumping Station.
- iii. Records of water level on the upstream and downstream side of Mitre gates and in the individual Pump bay behind sluice gates on continuous basis,
- iv. Performance evaluation sheet of the pumping station
- v. Record of tides and rainfall data in the catchment
- vi. Record of inlet flow and storm water discharge
- vii. Record of Diesel Consumption
- viii. Record of power consumption
- ix. Performance data of all equipment-
- x. Record of problems faced and trouble-shooting activities
- xi. Record of all repairs, maintenance and replacements of parts/equipment including spares consumed
- xii. Any other allied works required by Engineer during O&M
- xiii. Record of manpower deployed at site

The contractor shall prepare proper equipment wise logbooks and submit a daily, weekly and monthly report of plant regarding functioning of all units of plant.

Contractor's scope also includes obtaining renewal of various permissions, licenses, NOCs, approvals, permissions from all the concerned departments required for equipment, structures and pumping station as a whole. All costs incurred towards obtaining such renewals shall be borne by the Contractor.

2.2 Operation of pumping facility during monsoon period

Monsoon period will be considered as the period from 16th May to 15th October.

It is suggested that operation of pump(s) during flood relieving is always supported by following inputs recorded and available in PLC-SCADA system,

- Record of tide levels downstream of Mitre gates
- Position of Mitre gates (whether open or closed)
- Record of Storm water level in the drains / inlet channel upstream of Mitre gates
- Rain gauge data gathered by the rain gauges installed in the catchment area.

It is expected that the pumps are operated during rising tide when Mitre gates are in closed position and when it is raining in the catchment area. Operation of pumps when the tide is not rising, or, when the Mitre gates are open, or, when it is not raining in the catchment area will not be considered for payment unless there are specific instructions from the authorized MCGM personnel to operate the pumps. Such instructions shall be supported with reasons and shall be kept in records.

During Monsoon period, sequencing of pumps and DG sets is to be done in such a manner that all the pumps and DG sets are operated for equal period. The Any change / rectification / fine tuning in the operational logic based on gathered data and experience gained or as per specific instructions given by the Engineer shall be carried out by the Contractor during the period of Operation and Maintenance.

As specified in the tender document, the Contractor should arrange for manual measurement of head over pump bay outlet weir at every five minutes or at other regular intervals as approved by the Engineer and keep record of flow discharged by each pump. Flow measured can be roughly cross checked with rain fall data.

2.3 Operation of pumping facility during non-monsoon period

Non-monsoon period will be considered as the period from 16th October to 15th May. The pumps shall be operated during non-monsoon period as per Agreed Preventive maintenance schedule between Contractor and MCGM.

2.4 Maintaining of the records

All the information pertaining to Operation and Maintenance of the pumping facility shall be recorded in SCADA on continuous basis and shall be made available in printed formats to MCGM for verification of pump operating hours including for payment purpose. Various formats for recording information are to be submitted by the Contractor and have to be approved by MCGM. These formats are subject to change based on discussions between MCGM and the Consortium

The records maintained by the contractors as per # 2.2 and # 2.3 above shall be produced periodically to the Engineer-in-charge for proper monitoring as desired by him.

2.5 Maintenance schedule and Preventive Maintenance activities

The Contractor will submit and obtain approval on detailed monthly schedule of activities to

be covered under maintenance programme including preventive maintenance from the Engineer prior to commencement of Seven years Operation and Maintenance period of the Contract. All yearly tests should be completed, and report submitted before 15th April of the year so that sufficient time is available for any remedial actions. The maintenance programme will essentially include but will not be limited to following activities:

1. Cleaning of all pump bays including Inlet channel
2. Cleaning of Discharge channel and outlet bays of the Pumping station
3. Silt removal and cleaning of silt trap and nallah bed from screens to Mitre gates area
4. Operating of main submersible Pumps
5. Replacement of defective / damaged parts
6. Operating of DG sets
7. Replenishment of spares
8. Repairs or replacement of parts / equipment damaged if any during operation of Storm Water Pumping Station including Doors/windows/ rolling shutters, ventilators
9. Painting / of equipment, Structures, mounting frames, Hand railings, rolling shutters, Grills etc.
10. Operation of all EOT Cranes installed in the plant to ensure availability.
11. Lubrication and greasing of equipment
12. Checking of functionality of electrical and instrumentation systems and equipment, replacement of faulty relays, components, accessories etc. with a view to ensure uninterrupted operation during monsoon period.
13. Functioning of Protection systems
14. Checking of earthing grid voltage
15. Testing of continuity of Cables and HV tests of Panels
16. Functioning of cathodic protection system and replacement of sacrificing anode
17. Conducting testing of fire-fighting system and safety provisions.
18. Generating and maintaining all records

2.6 Minimum staff requirement during Operation and Maintenance period to be supplied by Contractor

Details of minimum staff required to be employed for the operation and maintenance of the pumping station during monsoon and non-monsoon period is given below. However, additional staff, if required for proper operation and maintenance, will be provided by the contractor without any additional charges.

Sr.	Personnel	Numbers		Main Task of the Personnel
		Non-Monsoon period	Monsoon period	
1	Plant Manager Engineering with 7 years of experience)	1	1	Coordination of activities for satisfactory performance of operation and maintenance and reporting to the Engineer-in-charge and responsible for the proper functioning & maintenance,
2	Assistant Engineer (B.E / Diploma- Mechanical Engineering with 5 years of experience)	1	1	Responsible for daily O&M, electrical and mechanical equipment and data collection.
3	Junior Engineer (Diploma/B.E. - Civil Engineering with 1 years of experience)	1	1	Responsible for daily O&M, civil units and data collection.
4	Junior Engineer (Diploma/B.E. Mechanical or Electrical Engineering with 2 years of experience)	7	2	Responsible for daily O&M, electrical and mechanical equipment and data collection.
5	Operators/Pump attendant (ITI Qualified with 3 years of experience)	7	4	Execution of specific tasks as indicated by the JE (E&M) for operating the different equipment
6	Electrician (ITI experience)	4	1	Responsible for maintenance of electrical equipment.
7	Fitter (Mech.) (ITI Qualified with 3	4	4	Responsible for maintenance of mechanical equipment.
8	Sweeper/Casual labour	14	4	Assistance to operator for cleaning plant premises, structures and equipment
9	Watchman	4	4	To protect the plant from the trespassers, animals etc.
10	Gardener	1	1	To maintain the garden/landscaping of the plant

3. General and Financial Terms & Conditions

After successful completion of trial runs and commissioning of the pumping facility and after certification of successful completion of „Part A” of the Contract, the contractor is to keep their staff engaged continuously without any break for Operation, Maintenance and Monitoring of the pumping plant for a period of Seven years on 24 hours x 365 days basis.

Philosophy of operation of pumping station shall be such that maximum relief from flooding and fast receding of flood water is achieved in the catchment area. To achieve this, the

pumping station should also be operated at nallah water levels much below the maximum nallah level in case of heavy rains instead of just to maintain nallah water level below maximum level.

The monthly payment towards Operation and Maintenance of the pumping facility as per terms of Contract, variation in the price of Labour, Material and Consumable and Fuel at prevailing month price level shall be calculated on the basis of guidelines given in the Special Conditions of the Contract Clause (Section 15, Volume 1 of the Contract document). Payment towards labour and materials & consumables shall be payable as per Section 3B, Schedule of Prices, Volume 3. Payment towards fuel component shall be payable as per actual pump operating hours logged in SCADA, both during Monsoon as well as non-monsoon period. 1% of payment from bill will be withheld to be released on renewal of all statutory licenses.

During entire Operation and Maintenance period of Seven years, it will be Contractor's responsibility to ensure availability of the entire installation for operation.

Plant and equipment covered under this contract shall be totally attended to by the contractor including any "Trouble Shooting" to ensure smooth and trouble-free operation.

Replenishment of all spares shall be done within 2 months of use. Replacement of damaged parts of any equipment including if necessary, the entire equipment as and when necessary will be done by the Contractor, to the satisfaction of the Engineer of the Contract.

Any kind of spares required during the entire Operation and Maintenance of seven years including 365 days defect liability period shall be supplied, replaced and replenished by the contractor at no extra cost to MCGM. All sorts of Tool & tackles, machinery including special tools and tackles required for proper and effective operation & Maintenance of the plant, shall be arranged by the contractor at his own cost.

If the contractor takes any equipment outside the site premises it will be the sole responsibility of the contractor for any damage or theft or loss of equipment and contractor shall bear all costs related to such mishaps.

For effective maintenance, the contractor shall employ sufficient staff with proper qualification. For his guidance the pattern and no. of minimum staff to be engaged is described in this chapter. However, the contractor shall provide any other expertise, labours, operators etc if so desired during entire period of operation and maintenance period.

The contractor shall abide by all central/state govt./Semi govt./Local Bodies rules regulations, pertaining to this contract, without any extra cost.

The contractor shall provide Round the Clock watch and ward of the entire premises including plants/machinery etc. during the entire period of seven years operation and maintenance.

In the event of any damage/loss of life/theft of property, due to negligence on the part of contractor, the contractor shall be solely responsible and liable for compensation and damages, regarding negligence and the decision of Engineer-in-charge shall be final.

The site will be open for inspection by the designated officers/official of the MCGM at all times during the contract period.

The staff employed will be provided with all the required safety equipment. It shall be

ensured that full safety measures are taken by the staff on duty. Staff employed shall be experienced and trained to handle the respective job/equipment.

The Storm Water Pumping station facility and the premises shall not be used by the Contractor for any other purpose than its intended use as described in the Contract document during the entire period of Operation and Maintenance. Use of the Storm Water Pumping Station facility, structures and or equipment / accessories installed inside the pumping facility by the Contractor for commercial purposes of any nature is not permitted.

Schedule of penalty for not meeting the requirements of operation and maintenance provisions in this document.

1. Penalty for Non-performance of the pumping station during operation and maintenance

Non-performance shall be construed when the level in the nullah is required to be reduced but it cannot be reduce for reasons attributable to the Contractor due to such as

- Non-operation of pump(s)
- Non-operation of DG set(s)
- Tripping of DG set(s)
- Non-operation of Mitre Gates
- Non-operation or inefficient operation of screens
- Non-operation of sluice gates
- Non-operation of related electrical system
- Non-operation due to any other reason

The level of nullah shall be measured just upstream of screen and the same shall be recorded on continuous basis in SCADA.

The calculation of penalty on account of non-performance of pumping facility shall be:

For instance if there are 7 pumps:

Total operating hours for monsoon months : $35 \times 7 \times 16 = 3920$ hours

Per hour operation cost = (cost of labour + cost of material and consumables + cost of fuel) / total operating hours

Penalty amount = $5 \times$ cost per hour for the period during which penalty is applicable X hours of non-performance

2. Penalty for Breakdown of Equipment:-

a) **Breakdown of Major Equipment:** If a breakdown of pump sets, DG sets, panels, mitre gates, sluice gates, screens and screen cleaning equipment, firefighting equipment etc., occurs and it is not possible to operate the pump and the Contractor does not repair the same within 8 days during monsoon or 15 days during non-monsoon period then, a penalty of 25% of the monthly payment of maintenance of pumping station (5.1b & 5.2b) of Volume 3, Section 3B of this Tender Document shall be levied as penalty for that month.

b) **Breakdown of Balance Equipment:** In case of breakdown of all equipment other than major equipment including but not limited to EOT cranes, grab bucket, submersible dewatering pump if the Contractor does not repair within 15 days during monsoon or 21 days during non-monsoon period a penalty of 10% of the monthly payment of maintenance of pumping station (5.1b & 5.2b) of Volume 3, Section 3B of this Tender Document shall be levied for that month.

3. Penalty for non-availability of fuel (diesel):

If contractor fails to operate the pumping station due to insufficient diesel stock i.e. if total stock is less than 7000 litres, then additional penalty of Rs. 3.0 lakh/day (apart from the non-performance penalty) will be levied to the contractor till diesel stock is enhanced.

4. Penalty for non-compliance of staff

If the contractor fails to provide the necessary staff as per clause 2.6 above, the penalty to be applied shall be 10% of the amount of recovery for the nos. of days of absence of the relevant staff.

5. Penalty for non-supply of vehicle during Operation & Maintenance period

In case of non-availability of vehicle a penalty of Rs. 3000/- per day per vehicle shall be imposed as specified in additional clause of Special Conditions of Contract.

6. Penalty for not carrying out desilting of nallah bed

Penalty of Rs. 5,00,000/- per year will be levied in case the Contractor fails to carry out desilting of the nallah bed before start of monsoon period as mentioned in Section 2A, Volume 2 of this Contract document.

Section 2F

Schedules

SECTION 2F - SCHEDULES

(The information to be filled in by the tenderer in the following forms will be used for Submission of Tenders, Instructions to Applicants, Section 6, Volume I.)

Descriptive offer of the Scheme *

- Schedule 1 : Schedule of Inventory of Spare Parts
- Schedule 2 : Functional Guaranties of the Equipment
- Schedule 3 : Resource Based Work Program
- Schedule 4 : Proposed Methodology for Execution of Work and Quality Assurance plan
- Schedule 5 : Safety, Health and Environment plan and measures to be adopted during execution
- Schedule 6 : Schedule of Deviation from the E-tendering documents

* The tenderer shall provide complete technical information of the scheme proposed by him.
The data sheet formats are given in Section 2G, Volume 2.

Schedule 1- Schedule of Inventory of Spare Parts

Schedule 2 - Functional Guarantee of the Equipment

I/We guarantee that the submersible pumps, Diesel Generating sets, Electrical panels and allied equipment / accessories being installed at Storm Water Pumping Station facility at Mogra will be reliable in operation and I/We undertake to replace, repair or adjust free of charge to the Municipal Corporation Greater Mumbai, any part of the plant supplied under the contract which fails to comply with the guarantees or requirements entered in the tender except fair wear and tear during testing and commissioning and during comprehensive Operation and Maintenance period until the certification of completion of Part B of the Contract.

I/We guarantee that all equipment installed at the Storm Water Pumping Station facility at Mogra are of the type which has been proved in service to be suitable for the duty required by the specifications and are manufactured and tested in accordance with the tender specifications and appropriate standard specification for other standards approved by the Engineer applicable at the time of testing.

I / we guarantee the performance of the Diesel Generator sets being supplied and installed by us at Storm Water Pumping Station facility at Mogra; for following operating parameters:-

Specific fuel consumption for each DG set <ul style="list-style-type: none">- at full load- at three quarter load- at half load- at no load	l/h	l/h	l/h	l/h
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I / we guarantee the performance of the Submersible Pump sets being supplied and installed by us at Storm Water Pumping Station facility at Mogra; for following operating parameters:-

Discharged flow in m ³ /sec	Combined flow of all 7 pumps when running simultaneously and measured at individual pump discharge weirs shall in no case will be less than 42m ³ /sec at available static head at site.
--	---

Signature _____ Tenderers signature & stamp

In the capacity of _____

Witness _____

Occupation _____

Address _____

Date : _____

Schedule 3 - Resource Based Work Program

(Tenderers shall provide their Resource based Work program along with PERT/CPM chart for 'Part A' of the Contract as mentioned under Packet "B" in Submission of Tenders, Instructions to Applicants, Section 6, Vol. 1, of this tender document including but not limited to all the activities as listed below).

1. Survey, Design, Detailed Engineering and Documentation

Item	Description	Start Date	End Date
1.1	Carrying out Topographic survey, Geotechnical Survey, Site Investigations, Submission of documents and their approval		
1.2	Hydraulic analysis (Physical modelling / Testing) including reports		
1.3	CFD Analysis and Report		
1.4	Submission and approval of Design, Detailed engineering and drawings as per tender specifications		
1.4.1	For Civil Works		
1.4.2	Mechanical Works		
1.4.3	Electrical Works, Instrumentation and automation works		
1.4.4	Comprehensive Operation & maintenance		
1.5	Manual		

2. Schedule for Civil Works

Item	Description	Start date	End date
2.1	Making uniform slope at bottom of the Nalla from existing bridge on Creek Road up to Silt Trap upstream of Coarse screen		
2.2	Retaining wall on the southern side of the Nalla from existing bridge on creek road up to 25m length downstream of pumping station		
2.3	Retaining wall on the northern side of the Nalla from existing bridge on creek road up to 25m length downstream of pumping station		
2.4	Approach Road bridge (class AA load) in the nalla 7.5m wide along with crash barrier from existing bridge on Creek Road up to storm water pumping station along with crash barrier		
2.5	Civil structure for silt pit, installations of mechanical bar screens and trash racks		
2.6	Internal road (class AA load) in the pumping station of 6m width along with crash barrier to connect every individual plant and equipment for its temporary storage, installation, erection, commissioning, operation and maintenance etc along with staff and personnel movement		
2.7	Foundation for all civil structures in the nalla bed		
2.8	Column and beam grid to support superstructures such as (i) Cellar Room, Main Electrical Rooms, Administration Office, Bachelor's Staff Quarters etc. (ii) Platform for Diesel Generators (iii) Maintenance Bay (iv) Laydown Areas, (v) Water Storage Tank for Fire-fighting (vi) Diesel Storage Tank (vii) Walkways and Pathways (viii) Approach to screenings skip, Silt Skip etc.		
2.9	Brick work, flooring, plastering, door / windows, painting, water proofing etc. for Electrical panel room cum administration building		
2.10	Construction of RCC channels for installation of equipment such as u/s roller gate, gate pumps, flap gates, and D/s Roller gates including necessary approaches, foundations, ladders, support for operating equipment, instruments etc. complete		
2.11	Civil Structure for installation of Mitre Gates		

Item	Description	Start date	End date
2.12	Maintenance Bay and Lay down areas		
2.13	Ancillary Works related to the Pumping Station		
a)	External water Supply		
b)	External Sanitary Network, pumping and transmission to nearest sewer line etc.		
c)	Compound (boundary) wall with foundation, Entry cum Exit Gate & Security Cabin		
d)	Macro Grading, Landscaping as directed by Employer's Representative		
e)	Jetting water tank & pump room		
f)	Potable water tank & pump room		
g)	Earthing pits		
h)	Labour toilet and wash area near mitre gate or screen structure		
i)	Enabling works such as coffer dams, diversion of nallahs / water course, touch pile, temporary roads as necessary during construction		
2.14	Any other item (please specify)		
2.15	Any other item (please specify)		
2.16	Any other item (please specify)		

3. Schedule for Mechanical Works

Item	Description	Start date	End date
3.1	Supply, installation & commissioning of Mechanical Bar screens, complete in all respect such as cleaning mechanism with local control panel with Emergency stop, on-off control station, PLC connectivity, rain protection shed complete in all respect as per design requirements of Storm Water Pumping Station and as specified in Volume 2, Section 2C		
3.2	Supply, installation & commissioning of Trash Racks complete in all respect such as cleaning mechanism (water jetting) with local control panel with Emergency stop, on-off control station, PLC connectivity, rain protection shed complete in all respect as per design requirements of Storm Water Pumping Station and as specified in Volume 2, Section 2C		
3.3	Supply, installation & commissioning of Stop logs for Inlet bay and Mitre gate area as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.4	Supply, installation & commissioning of roller gates with actuators, mounting frames, and local control panel with on-off control station, PLC connectivity complete in all respect as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.5	Supply, installation & commissioning of flap gates with actuators (as standby arrangement), mounting frames, and local control panel with Emergency stop on -off control station, PLC connectivity complete in all respect as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.6	Supply, installation & commissioning of submersible axial flow pumps complete with all necessary accessories, Mounting Arrangement, pump monitoring unit with PLC connectivity, emergency stop complete in all respect as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.7	Supply, installation & commissioning of D.G. Set(Main) with AMF panel, emergency stop and local on-off control station, PLC connectivity, acoustic enclosure, engine exhaust arrangement as specified complete in all respect as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		

Item	Description	Start date	End date
3.8	Supply, installation & commissioning of D.G. Set(Aux) with AMF panel, emergency stop, PLC connectivity, acoustic enclosure, engine exhaust arrangement as specified complete in all respect as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.9	Supply, installation & commissioning of 30 m. height stack with supporting steel structure, lightning protection and aviation lighting for D.G. set as required as per requirements of Storm Water Pumping Station design as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.10	Supply, installation & commissioning of main diesel storage tank, Fuel Transfer System from Main Diesel Tanks to Day Tank including level sensors, control valves, vents, pumps, local control panel, PLC connectivity etc. complete in all respect for D.G. Set (Main) & DG set (Aux.) as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.11	Supply, installation & commissioning of 990 litres Day tanks & Fuel Transfer System from Day Tank to D.G. Sets (Main) including level sensors, PLC connectivity, control valves, vents, return pipe line etc. complete in all respect as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.12	Supply, installation & commissioning of Day tank & Fuel Transfer System from Day Tank to D.G. Set (Aux) including level sensors, PLC connectivity, control valves, vents etc. complete in all respect as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.13	Supply, installation & commissioning of EOT crane including rail section complete with Control pendant, control panel, cables, maintenance platform, caged ladder, extension structure and allied work for Trash Rack and Silt Bucket operation as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.14	Providing and Installation of Superstructure above Mitre gates structure for accommodating EOT Crane covering all Mitre gates including provision of GI gratings, SS316 hand railings, area lighting, approach ladder, cathodic protection etc. complete		

Item	Description	Start date	End date
3.15	Supply, Installation and Commissioning of EOT crane including rail section, Control pendant, control panel, maintenance platform, caged ladder, extension structure, cables and allied work for Mitre gates and Stop logs as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.16	Supply, installation & commissioning of Submersible dewatering Pump with lifting chain and guide pipe as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.17	Supply, installation & commissioning of Tidal Control Gates (Mitre Gates) including cathodic protection, control gear box with actuator, manual override and stop logs as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.18	Supply, installation & commissioning of Fire Fighting system including fire hydrant, valves, pumps / raw water tank, control panel, alarms etc. complete as per requirements of Storm Water Pumping Station design and as specified in Volume 2 and as approved by fire officer		
3.19	Supply, installation & commissioning of Pressure jetting system arrangement including stand posts, piping, pumps, valves and specials etc complete with overhead water tank for inlet bay, pump bays as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2C		
3.20	Any other item (Please specify)		
3.21	Any other item (Please specify)		
3.22	Any other item (Please specify)		
3.23	Any other item (Please specify)		

4. Schedule for Electrical, instrumentation and Automation Works

Item	Item Description	Start date	End date
4.1	Supply, installation & commissioning of 6.6 kV switchgear for Main Pumps with spare panels as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.2	Supply, installation & commissioning of 6.6kV FCMA Soft Starters complete with PFC capacitors & dynamic compensators for submersible pump motors with spare soft starter, PLC based as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.3	Supply, installation & commissioning of Neutral Grounding Resistors rating 6.6 kV, to suit required Capacity of D.G. sets as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.4	Supply, installation & commissioning of 415 V, 62.5 kVA Prime rated black start DG set complete with acoustic enclosure, local control panel, sub-base integral day-tank and other fittings & accessories, conforming to CPCB norms as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.5	Supply, installation & commissioning of 6.6 kV switchgear for DG system with spare panels as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.6	Supply, installation & commissioning of DG set Control & Protection Panel complete with GCU to suit required Capacity of D.G. sets as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.7	Supply, installation & commissioning of Auto synchronising, Auto load sharing system for DG set and as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.8	Supply, installation & commissioning of 415V Switchgear for pumping station as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		

Item	Item Description	Start date	End date
4.9	Supply, installation & commissioning of 415V Switchgear for DG installation as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.10	Supply, installation & commissioning of 6.6/0.433 kV, transformer of rated capacity for DG power as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.11	Supply, installation & commissioning of Local Control Stations as specified in Volume 2, Section 2D		
4.12	Supply, installation & commissioning of 6.6 kV cables, 3C X 240 mm sq. with cable termination kits, cable glands for 6.6 kV system as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.13	Supply, installation & commissioning of Automatic Power Factor Correction (APFC) equipment at 415V level as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.14	Supply, installation & commissioning of 110V SMF battery of adequate AH capacity with battery charger and DCDB as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.15	Supply, installation & commissioning of PLC and SCADA system with cabling and UPS system with back up SMF batteries including differential level measurement system and ultrasonic level measurement system for complete plant control as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.16	Supply, installation & commissioning of LV power and control cables for the entire installation as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.17	Supply, installation & commissioning of equipment / panel earthing & Earthing grid complete as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.18	Supply, installation & commissioning of Lighting system – Indoor, Outdoor & area lighting, including lighting fixtures & fittings, fans, 415V ACDBs` etc. Complete for entire pumping station as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		

Item	Item Description	Start date	End date
4.19	Supply, installation & commissioning of Cable carrier (trays) system for 6.6 kV & LT cables including tray covers, supports, canopy etc. Complete as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.20	Supply, installation & commissioning of Lightning Protection System complete as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.21	Supply, installation & commissioning of Air-conditioning and ventilation works for rooms as per requirements as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.22	Supply, installation & commissioning of Safety equipment as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.23	Supply, installation & commissioning of 415 V panel for Fire Fighting pump and Jockey pump as per requirements of Storm Water Pumping Station design and as specified in Volume 2, Section 2D		
4.24	CCTV surveillance system comprising of weatherproof CCTV cameras, memory back up, desk top computer with CPU and Flat screen monitor, cables, UPS of adequate capacity as per requirements of Storm Water Pumping Station		
4.25	Approval by electrical inspector for entire electrical installation		
4.26	Solar power generation and distribution system including solar panels on roof structures within the Storm Water Pumping Station		
4.27	Any other item (Please specify)		
4.28	Any other item (Please specify)		
4.29	Any other item (Please specify)		

5. Schedule for Commissioning of Pumping Station

Item	Description	Start Date	End Date
5.1	Performance trial of Entire Pumping station in Manual Mode		
5.2	Performance trial of Entire Pumping station in Auto Mode		

Schedule 4 - Proposed Methodology for Execution of Work and for Quality Assurance Plan

(Tenderers shall provide detailed write up on their Proposed Methodology for execution of work and details of Quality Assurance plan that they will adopt during the execution of the work.)

Schedule 5 - Safety, Health and Environmental assurance plan and measures to be adopted during execution

(Tenderers shall provide detailed write up on their Safety, Health and Environmental assurance plan and measures they will adopt during Execution of the project.)

Schedule 6 - Schedule of Deviation from the tendering documents

Tenderers shall state briefly any deviations from the specifications contained in the main offer. If the deviations are discussed in the covering letter then reference to the covering letter shall be made below.

Item or Clause	Deviation	Covering Letter Page

Section 2G

Datasheets

SECTION 2G – DATA SHEETS

1.1 Mechanical Equipment - Data Sheets

(TO BE FURNISHED BY THE BIDDER)

1 Screens

Sr.	Item Description	Unit	Technical Particulars Required by MCGM	Technical Particulars offered by the Contractor
(a)	General			
(i)	Make		As per list of approved Manufacturer	
(ii)	Model		Furnished by Bidder	
(iii)	Type		Mechanical	
(iv)	Number	nos.	Furnished by Bidder	
(v)	Width of each screen panel	m	4 (max)	
(vi)	Height of each screen panel	m	6 (min)	
(vii)	Size of individual screen bar	mm x mm	Furnished by Bidder	
(viii)	Clear spacing between each bar	mm	40 (max.)	
(ix)	Material of construction of Screens and screen cleaning arrangement		Furnished by Bidder	
(x)	Drive rating for each screen panel	HP		
(xi)	Clear size of racking tines of screen cleaning mechanism	mm		
(xii)	Time required for one cleaning cycle	seconds	Not more than 20	
(xiii)	Velocity of flow through the screen opening considering 25% clogging	m /s	Not to exceed 1.2 m per sec.	
(xiv)	Type of screen cleaning mechanism		Positive raking front raking / back Raking	

Sr.	Item Description	Unit	Technical Particulars Required by MCGM	Technical offered by the Contractor
(xv)	No. of containers provided for removal of screenings	Nos.		
(xvi)	Belt conveyer for removal of screenings			
	- Width of belt	Mm		
	- Length of conveyer system	m		
	- Drive Rating	HP		

2 Storm water Pump sets

Sr.	Item Description	Unit	Technical Particulars Required by MCGM	Technical offered by the Contractor
(a) General				
(i)	Make		As per list of approved Manufacturer	
(ii)	Model			
(iii)	Type		Submersible Type Horizontal / vertical Axial flow pump	
(iv)	Number	nos.	7	
(v)	Specific gravity of fluid			
(b) Performance				
(i)	Capacity	cum/s	6	
(ii)	Total Head	Meter	6	
(iii)	Efficiency	%	Furnished by Bidder	
(iv)	Maximum pump input at 50 Hz for single pump operation		Furnished by Bidder	
(v)	Shut off Head	Meter	Furnished by Bidder	
(vi)	Speed	RPM	Furnished by Bidder	

Sr.	Item Description	Unit	Technical Particulars Required by MCGM	Technical Particulars offered by the Contractor
(vii)	Size of incompressible solids that can be handled	mms	100 mm diameter	
(viii)	Motor Rating	kW/HP	Furnished by Bidder	
(ix)	Motor Efficiency	%	Furnished by Bidder	
(x)	W.H.P. of Pumps at Duty Point		Furnished by Bidder	
(xi)	B.H.P. of Pumps at Duty Point		Furnished by Bidder	
(xii)	kW I. Of Motor		Furnished by Bidder	
(c) Construction				
(i)	Type of Impeller		Propeller	
(ii)	Number of Impeller vanes		Furnished by Bidder	
(vi)	Weight	kg	Furnished by Bidder	
(d) Materials of Construction				
(i)	Impeller			
(ii)	Casing		As per tender specs	
(iii)	Shaft			
(vi)	Seals			
(e) Testing and Inspection				
(i)	Pump Performance testing Standard			
(f) Performance				
(i)	Maximum velocity of vibration	mm/sec	Furnished by Bidder	
(ii)	Maximum noise level	dBA	Furnished by Bidder	

3 Diesel Engine Driven Power Generation Set

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical offered Particulars by the Contractor
(a)	D.G. Set Manufacturer			
(i)	Type		Industrial	
(ii)	Quantity	Nos.	4 min.	
(iii)	Weight of the DG Set	kg	To be furnished by Bidder	
(iv)	DG Set dimensions (l x b x h)	mm	To be furnished by Bidder	
(v)	Acoustic Dimensions Enclosure	mm	To be furnished by Bidder	
(b)	Diesel Engine			
(i)	Manufacturer		As per approved list of manufacturers	
(ii)	Applicable Standard			
(iii)	Type of Engine			
(iv)	Engine rating normally aspirated	kW	To be furnished by Bidder	
(v)	Maximum engine rating	kW	To be furnished by Bidder	
(vi)	Period for maximum engine rating	Hour		
(vii)	Time interval between successive starts	sec		
(viii)	Maximum permissible starting time for Attaining full speed and closing of generator breaker	sec		
(ix)	Method of starting			
(x)	Combined shaft system critical speed	Rpm	To be furnished by Bidder	
(xi)	Combined shaft system moment of inertia	kg – m ²		
(xii)	Material of Construction for Bed Plate Crank Case Cylinder Head Cylinder Liner			

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical Particulars offered by the Contractor
	Crankshaft Connecting rod Piston Camshaft Flywheel Valve Gear			
(xiii)	Specifications of fuel recommended			
(xiv)	Rated output at site conditions (Prime Rating)		To be furnished by Bidder	
(xv)	Overload	%	50% overload capability for 10 seconds	
(xvi)	Mechanical efficiency			
(xvii)	Thermal efficiency			
(xviii)	Volumetric efficiency			
(xix)	Safety protection Over speed trip Low lube oil pressure trip High cooling water temp.			
(xx)	Strokes	Per minute		
(xxi)	Maximum period for which engine can operate without cooling water after starting	Minute		
(xxii)	Specific Fuel consumption for each DG set	L/h	To be furnished by Bidder	
	- at full load	L/h	To be furnished by Bidder	
	- at three quarter load	L/h	To be furnished by Bidder	
	- at half load	L/h	To be furnished by Bidder	
	- at no load	L/h	To be furnished by Bidder	
(xxiii)	Lubrication System			
(xiv)	Lube oil consumption at rated Load	L/h		
(xv)	Type of governor	Type		

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical Particulars offered by the Contractor
	Manufacturer			
	Load sharing Feature	Yes/No		
	Adjustable droop Feature	Yes/No		
	Prescribed speed band +/- rated			
	Speed			
(xvi)	Method of Cooling Type of Heat Exchanger Details of Heat Exchanger			
(c)	Generator			
(i)	Manufacturer		As per approved list of manufacturers	
(ii)	Applicable Standard			
(iii)	Type & Enclosure			
(iv)	Output Rating	kVA		
(v)	Rating (duty)			
(vi)	Maximum rated kW of Motor that can be started 'Direct online' when generator is Unloaded 50% loaded 85% loaded		To be furnished by Bidder	
(vii)	Maximum time required for building up rated voltage from standstill and closing of DG breaker		To be furnished by Bidder	
(viii)	Excitation at MCR Voltage Current			
(ix)	Rise in Voltage when Full load is thrown off With AVR			
(x)	Current (continuous)			
(xi)	Rated Power factor		0.8	
(xii)	Efficiencies - %		To be furnished by	

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical offered by the Contractor
	At maximum capacity & rated PF At 75% MCR and rated PF At 50% MCR and rated PF At 25% MCR and rated PF		Bidder	
(xiii)	Temperature Rise Cooling medium temp Armature winding above cooling medium Field winding above cooling medium Cooling air from the windings		To be furnished by Bidder	
(xiv)	Insulation -Type & Class for Stator & Rotor			
(xv)	IP class of enclosure			
(xvi)	Automatic voltage regulator		Dead band type	
(d) Diesel Storage Tank capacity				
(i)	Day Tank	Liter	990	
(ii)	Main Tank	Liter	30,000 (min.)	

4 EOT Crane for Grab bucket & Trash Racks

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical offered by the Contractor
(a)	General			
(i)	Capacity	Ton	Min. capacity twice the max. weight of equipment	
(ii)	Make		As per approved list of manufacturers	
(iii)	Type & Class of crane			
(iv)	Lift	m		

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical offered by the Contractor
(v)	Speed Hoist (Main) Hoist (Slow) Cross Travel (Main) Cross Travel (Slow) Long Travel (Main) Long Travel (Slow)			
(vi)	Head Room			
(vii)	Hoist Rope			
(viii)	No. of Falls			
(ix)	Factor of Safety			
(x)	Diameter in mm			
(b)	Brake			
(i)	Type			
(ii)	Make			
(iii)	Holding Torque	N-m	To be furnished by Bidder	
(c)	Hook			
(i)	Type			
(ii)	Material		As per tender specs	
(iii)	Hook Approaches - Left hand, mm - Right hand, mm			
(iv)	Applicable Standard		IS 8610 or BS:2903 / BS:3017	

5 EOT Crane for Mitre Gates:

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical offered by the Contractor
(a)	General			
(i)	Capacity	Ton	Min. capacity twice the max. weight of equipment	

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical Particulars offered by the Contractor
(ii)	Make		As per approved list of manufacturers	
(iii)	Type & Class of crane			
(iv)	Lift	m		
(v)	Speed Hoist (Main) Hoist (Slow) Cross Travel (Main) Cross Travel (Slow) Long Travel (Main) Long Travel (Slow)			
(vi)	Head Room			
(vii)	Hoist Rope			
(viii)	No. of Falls			
(ix)	Factor of Safety			
(x)	Diameter in mm			
(b) Brake				
(i)	Type			
(ii)	Make			
(iii)	Holding Torque	N-m	To be furnished by Bidder	
(c) Hook				
(i)	Type			
(ii)	Material		As per tender specs	
(iii)	Hook Approaches - Left hand, mm - Right hand, mm			
(iv)	Applicable Standard		IS 8610 or BS:2903 / BS:3017	

6 Drainage Pump set

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical Particulars offered by the Contractor
(a) General				

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical Particulars offered by the Contractor
(i)	Make		As per approved list of manufacturers	
(ii)	Model		To be furnished by Bidder	
(iii)	Type		Portable Submersible type	
(iv)	Number	nos.	1 working + 1 standby	
(b)	Performance			
(i)	Capacity	cum/hr	Min. 20 m3/hr	
(ii)	Total Head	meter	10m (min)	
(iii)	Efficiency	%	To be furnished by Bidder	
(iv)	Maximum pump input at 50 Hz for single pump operation			
(v)	Shut off Head	meter		
(vi)	Speed	rpm	To be furnished by Bidder	
(vii)	Size of solids that can be handled	mm	100 mm	
(viii)	Motor Rating	Kw/HP	To be furnished by Bidder	
(c)	Construction			
(i)	Type of Impeller		Non - clog	
(ii)	Number of Impeller vanes		To be furnished by Bidder	
(iii)	Type of insulation		To be furnished by Bidder	
(iv)	Suction/discharge	mm	To be furnished by Bidder	
(vi)	Weight	kg	To be furnished by Bidder	
(d)	Materials of Construction			
(i)	Impeller		To be furnished by Bidder	
(ii)	Casing		To be furnished by Bidder	

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical Particulars offered by the Contractor
(iii)	Shaft		To be furnished by Bidder	
(vi)	Seals		To be furnished by Bidder	
(e)	Testing and Inspection			
(i)	Pump Performance testing Standard			
(f)	Performance			
(i)	Maximum velocity of vibration	mm/s		
(ii)	Maximum noise level	dBA		

7 Technical Data Sheet for Auxiliary Diesel Generator Set

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical Particulars offered by the Contractor
1.0	Prime mover			
2.0	Quantity required			
3.0	Service			
4.0	Rating			
5.0	RPM			
6.0	Voltage			
7.0	Voltage variation / regulation Steady state – slow variation In load (0.0% to 100% at P.F. 0.8)			
8.0	Voltage deep (sudden load application 0.0% to 100% at P.F. 0.8)			
9.0	Frequency			

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical offered by the Contractor	Particulars by the
10.0	Frequency variation / regulation				
11.0	Temperature rise				
12.0	Alternator Insulation Material				
13.0	Flywheel				
14.0	Vibration damper				
15.0	Fuel pump air cleaner				
16.0	Fuel pump				
17.0	Oil filter, fuel filter etc.				
18.0	Lube oil pump				
19.0	24 V DC electrical system consisting of SMF lead acid battery set and suitable charger				
20.0	Safety controls				
21.0	Residential type Silencer				
22.0	Acoustic Hood				
23.0	AMF panel with breaker				
24.0	Coupling				
25.0	Instrument panel consist of a) Starter switch with key b) Lube oil temp. gauge c) Water temp. gauge d) Lube oil pressure gauge e) Tacho cum Hour meter				
26.0	Fuel tank				
27.0	Battery charger				
28.0	Engine testing a) At shop b) At site				
29.0	Tool kits				

Sr.	Description	Unit	Technical Particulars Required by MCGM	Technical offered by the Contractor	Particulars by the Contractor
30.0	Literature (Two sets each) a) Operation & maintenance manual b) Parts catalogue / list				

1.2 Electrical Equipment - Datasheets

1 POWER LOAD LIST

2 6.6 KV SWITCHGEAR PANEL

Item	Description	Unit	Requirement of MCGM	Data to be filled in by the Bidder

Item	Description	Unit	Requirement of MCGM	Data to be filled in by the Bidder
1.0	DESIGN			
1.1	Rated Voltage	V	6600	
1.2	Rated frequency	Hz	50	
1.3	Rated current	A	As per design requirement	
1.4	Medium of switching		Vacuum	
1.5	Rated short circuit withstand current			
	- rms for 1 sec.	kA		
	- Max. peak	kA		
1.6	Auxiliary voltages			
	- Internal/external			
	- Control voltage	V	110 V	
	- Protection	V	110 V	
	- Signalling	V	110 V	
2.0	Relays			
2.1	Metering	{}		Bidder shall submit detailed list of relays, contactors, CTS and PTs (type, VA, ratio) selector switches and meters shall be provided for each incoming/ outgoing feeder as per single line diagram and project specific requirements
2.2	Access			
	- Front only			
	- Back			
	- Both		Both	
2.3	Type tests			
	- All required		All required	
	- Certificate		To be attached with the bid for same type of equipment.	

3 6.6/0.433 KV DISTRIBUTION TRANSFORMER

Item	Description	Unit	Requirement of MCGM	Data to be filled in by the Bidder
1.0	Installation			
	- Indoor/Outdoor		Indoor	
	- Under Sunshade/Without Sunshade			
	- Area Classification			
2.0	Cooling			
	- Self/fan cooled			
	- Oil/Air		Air	
2.1	System			
	- 3 Phase			
	- Unearthed			
	- Impedance earthed			
	- Solidly earthed		Solidly earthed	
2.2	Rated Voltages:			
	Primary			
	- Line to line	V	6600	
	- Line to earth	V		
	Secondary			
	- Line to line	V	415	
	- Line to earth	V		
2.3	Rated frequency	Hz	50	
2.4	Tap Changer			
	- Off-circuit		Off-circuit	
	- On load			
	- Range			
	- No. of positions			
2.5	Vector group		Dy11	
2.6	Parallel operation	Yes/ No	No	
2.7	Accessories			
	- Inspection Cover		NR	
	- Rating Plate		R	
	- Terminal marking plate		R	
	- Two earthing terminals		R	
	- Lifting lugs		R	
	- Drain valve		R	
	- Dehydrating breather		R	
	- Oil level prismatic		R	
	- 2 Thermometer pocket		R	

Item	Description	Unit	Requirement of MCGM	Data to be filled in by the Bidder
	- Oil filling hole with cover - Conservator - Air release plug - Jacking pads - Filter valves		R	
	- Weatherproof marshalling box with internal connecting cabling		NR	
	- Cable box air insulated on HV Side with disconnecting chambers with suitable lugs & glands		R	
	- Winding temp. indicator with Mercury switches for alarm and trip		NR	
	- Oil temperature indicator with mercury switches for alarm and trip		R	
	- Magnetic oil level gauge with mercury switch for Alarm Dial Size of magnetic oil level gauge		R	
	- Pressure relief valve with alarm contacts		R	
	- Buchholz Relay with Alarm and Trip contacts		R	
	- Neutral CT – 2 Nos. Mounted on Tank /L.V Bus Box		R	
	- Wheels - Flat/flanged - Unidirectional/Bi-directional - Quantity - Gauge		R	
4	Losses			
a)	No load loss on principal tap at 100% rated voltage & frequency subject to +10% tolerance as per IS	kW (MAX)		
b)	Load loss on principal tap & rated current at 75°C winding temp. (guaranteed subject to +10% tolerance as per IS)	kW (MAX)		

4 415 V SWITCHGEAR

Sr.	Item	Unit	Requirement of MCGM	Data to be filled in by the Bidder
A	General Construction of Switchgear			
a)	Manufacturer/Assembler		L & T/ SIEMENS / Schneider / Elecmech / Elma / Hitec	
b)	Quantity offered	No.		
c)	Switchgear designation			
d)	Applicable Standards		Ref. cl. 5.1	
e)	Installation Indoor/Outdoor		Indoor	
f)	Single front or double front		Single front	
g)	Module Construction		multi-tier	
h)	Degree of Protection (As per IS:2147)		IP-52	
i)	Cable Entry - for incoming cables - for outgoing cables		Bottom	
j)	Painting / Powder Coating		phosphate coating	

5 SHUNT CAPACITOR

Sr.	Item	Unit	Requirement of MCGM	Data to be filled in by the Bidder
(i)	Name of manufacturer		MALDE / L & T (MEHER) / ASIAN / SIEMENS	
(ii)	Manufacturer's type and designation			
(iii)	Reference Standards		IS: 2834/BS1650	
(iv)	Rated VAR capacity of the capacitor bank			
(v)	Rated voltage	V	415	
(vi)	Rated frequency	Hz	50	
(vii)	Output of the capacitor bank at rated voltage	kVAr		
(viii)	Capacity of Bank	Micro farads		
(ix)	Type of capacitors			
(x)	Type test certificates enclosed	Yes / No	Yes	

6 CAPACITOR CONTROL PANEL

Sr.	Item	Unit	Requirement of MCGM	Data to be filled in by the Bidder
(i)	Manufacturer / Assemble		MALDE / L & T (MEHER) / ASIAN / SIEMENS	
(ii)	Quantity	No.	1	
(iii)	Enclosure Protection			
(iv)	Auto Power factor relay			
	-Manufacturer			
	-Type			
	-Number of stages			

7 CABLES

Sr.	Item	Unit	Requirement of MCGM	Data to be filled in by the Bidder
1.1	6.6 kV XLPE UNEARTHED POWER CABLE			
a	Manufacturer		CCI / FORT GLOSTER / POLY CAB / TORRENT / ASIAN (RPG) / UNIVERSAL	
1.2	650/1100V grade XLPE INSULATED POWER CABLES			
a	Manufacturer & cable type		CCI / FORT GLOSTER / POLY CAB / TORRENT / ASIAN (RPG) / UNIVERSAL	
b	Rated Voltage			
1.3	650/1100V grade PVC INSULATED CONTROL CABLES			
a.	Manufacturer & cable type (*)		CCI / FORT GLOSTER / POLY CAB / TORRENT / ASIAN (RPG) / UNIVERSAL	
	Any other (Please Specify) (*)			

(*) Bidders shall furnish complete cable schedule giving type, size, manufacturer, lengths, method of laying between various units to facilitate technical evaluation of bids.

8 LIGHTING SYSTEM

Sr.	Item	Unit	Requirement of MCGM	Data to be filled in by the Bidder
A	Lighting Fittings			
(i)	Manufacturer		PHILIPS / WIPRO / BAJAJ / CGL	
B	Emergency Lighting Fittings			
(i)	Manufacturer		PHILIPS / WIPRO / BAJAJ / CGL	
(ii)	Rated voltage	V	415	
(iii)	Light output duration			
(iv)	Lamp rating (AC/DC)			
(v)	Catalogue containing technical literature enclosed Yes/No		Yes	

9 CABLE TERMINATIONS

Sr.	Item	Unit	Requirement of MCGM	Data to be filled in by the Bidder
(i)	Gland Type			
(ii)	Lugs			
(iii)	Application Indoor / Outdoor		Both	

10 CABLE TRAY

Sr.	Item	Unit	Requirement of MCGM	Data to be filled in by the Bidder
a.	Manufacturer			
b.	Type			
c.	Material		FRP cable trays	
d.	Finish			
e.	Tray width		As per requirement	

11 EARTHING AND LIGHTNING PROTECTION SYSTEM

Sr.	Item	Unit	Requirement of MCGM	Data to be filled in by the Bidder
(i)	Earthing conductor buried in			
	Ground			
	- Material			
	- Size			
(ii)	Earthing conductor above ground up to equipment terminal			
	- Material			

	- Size			
(iii)	Earth Electrode test pits			
	- Material			
	- Size			
	- Type of Electrode			
(iv)	Lighting protection conductor			
	- Material			
	- Size			

12 ANY OTHER ITEM NOT COVERED ABOVE

Sr.	Description	Unit	Details
	Please specify relevant information		

1.3 Instrumentation - Datasheets

Sr. No.	Description	Unit	Particulars
	Level Measuring System		
(a)	Ultrasonic Type Make and Model Beam Angle Country of Origin		
(b)	Capacitance Type Make and Model Country of Origin		
(c)	Conductivity Type Make and Model No. of electrode Country of Origin		
(d)	Float type Level Gauge Make and Model Float Material Country of Origin		
4.1.2	Digital Level Display Unit		
(a)	Make and Model		
(b)	Country of Origin		
4.1.3	Pressure Gauges		
(a)	Make and Model		
(b)	Range	kg/cm ²	
(c)	Country of Origin		
4.1.4	Pressure Transmitter with local indication		
(a)	Make and Model		
(b)	Range	kg/cm ²	
(c)	Country of Origin		
4.1.5	Digital Pressure Indicator		
(a)	Make and Model		
(b)	Repeat Transmission output		
(c)	Country of Origin		
4.1.6	Pressure Switches		
(a)	Range		
(b)	Make and Model		

Sr. No.	Description	Unit	Particulars
(c)	Country of Origin		
4.1.7	Flow Measuring System		
(a)	Electromagnetic Flowmeter		
	Make and Model		
	Accuracy		
	Flow integrator and display unit		
	Make and Model		
	Country of Origin		
	Instrument Control Panel with Alarm Annunciator		
	Make and Model		
	Pre- Fabricated		
	Country of Origin		
	Instrument Junction Boxes as per site requirements		
	Make and Model		
	Instrument enclosures		
	Country of Origin		
	Instrument Enclosures as per site requirements		
	Make and Model		
	Instrument enclosures		
	Country of Origin		
	Local Push button Station		
	Make and Model		
	Country of Origin		
4.1.15	Control & Automation System: (Hot Standby CPU) Programmable Logic Controller		
(a)	Make and Model & Series: Hot standby Offered : Country of Origin:		
(b)	(i) Digital Inputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	

Sr. No.	Description	Unit	Particulars
(c)	(i) Digital outputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	
(d)	(i) Analog Inputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	
(e)	(i) Analog outputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	
	Memory		
	Redundant Power Supply Modules, (i) Make (ii) Model No (iii) Country of Origin		
	CPU (i) Make (ii) Model No (iii) Country of Origin		
	Communication Modules (i) Make (ii) Model No (iii) Country of Origin		

Sr. No.	Description	Unit	Particulars
	Portable Industrial Programming Unit (Laptop-16" screen) loaded with licensed latest Windows operating system, PLC programming software & SCADA software, MS Office, Antivirus software, with all accessories required to connect to PLC and to monitor &control the pumping station if required, etc)		
	Interface/integration Redundant GPRS communication equipment with ISPS, CP-024 & MIS-2 contracts (i) Make & Model: (ii) Country of Origin: (iii) Redundancy offered:		
(c)	Printers (A-3 Size Printer) - OFFLINE - ONLINE - Country of Origin	Nos	
4.1.23	SOFTWAREs SCADA software: Version: Country of Origin: PLC Programming Software: Version: FBD Supported: Make & Origin (Contractor shall name Make & Origin without fail)		

Sr. No.	Description	Unit	Particulars
4.1.24	SCADA Server Hardware Details CPU Configuration Make /Model Monitor size Monitor make Country of origin		
4.1.25	SCADA clients/Operator machines Hardware Details CPU Configuration Make /Model Monitor size Monitor make Country of Origin		
4.1.27	SCADA System Console (i) Make (i) Model (ii) Country of Origin		
4.1.28	Large screen display, 65" LED Screen		
	Make and Model:		
	Dimension/Size:		
	Video switcher / Controller Considered:		
	Country of Origin:		
4.1.32	Alarm Annunciator		
(a)	Make and Model		
(b)	Country of Origin		
(c)	No. of Points		
4.1.33	Ethernet Managed Switch Printers (i) Make /Model (ii) No of Ports (iii) Country of Origin		

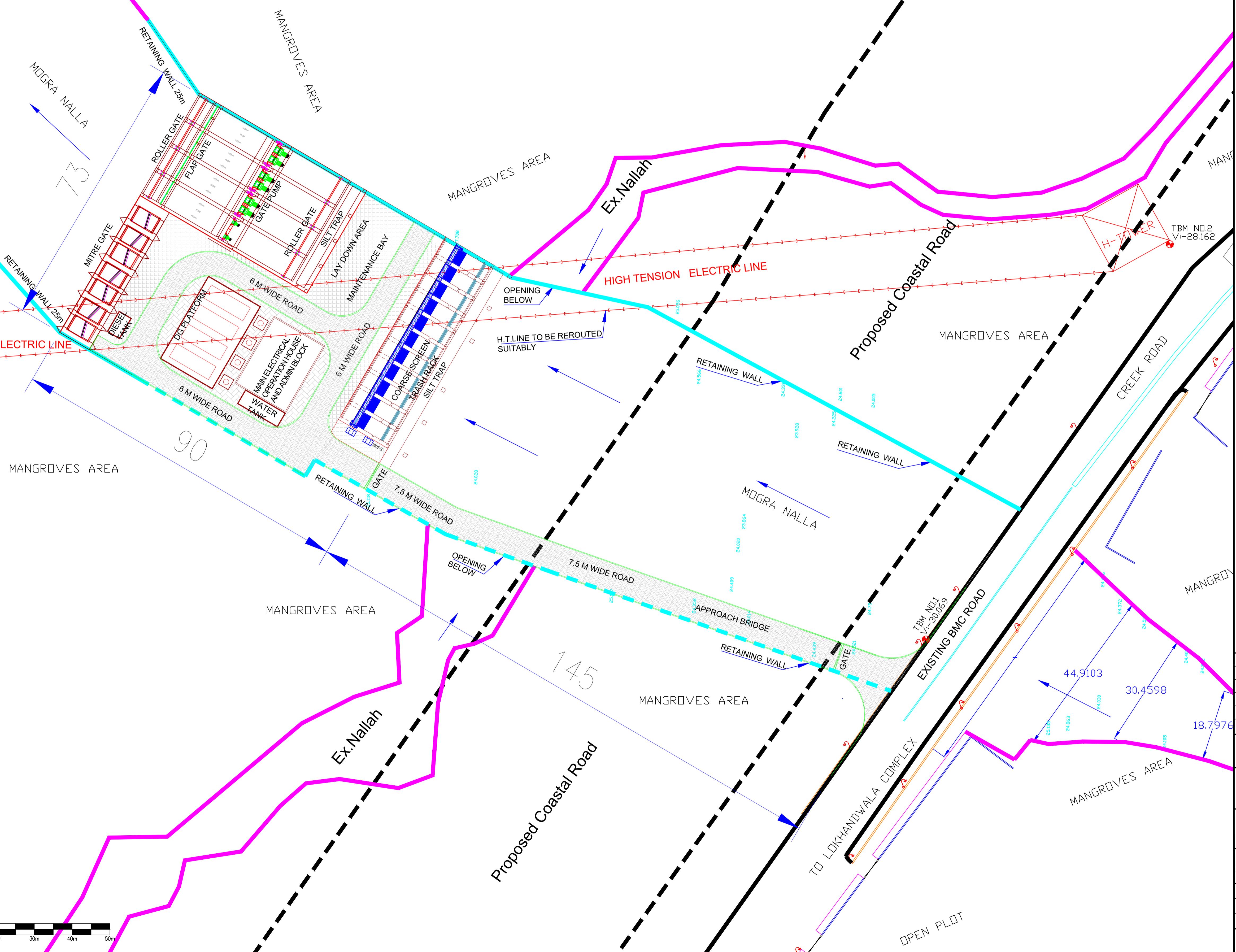
Sr. No.	Description	Unit	Particulars
4.1.34	CCTV Workstation Details (i) CPU Configuration (ii) Make /Model (iii) Monitor make (iv) Monitor Size (iv) Country of Origin		
4.1.35	Uninterruptable Power Supply for complete ICA equipment (Inclusive of all field Instruments, Control and Automation Equipment, GPRS Communication equipment)		
	Make and Model		
	Capacity		
	Backup time considered		
	No of batteries		
	Country of Origin:		
4.1.36	Surge Protection Devices		
(a)	Surge Rating	kA	
(b)	Make/Model		
(c)	Country of Origin:		
4.1.37	Instrumentation and Control Cables Make No of Cores Type Country of Origin Armoured cables are considered:		
4.1.38	Cable trays Make: Type: Country of Origin:		
4.1.39	Instrument Enclosures Make: IP Rating: Country of Origin:		

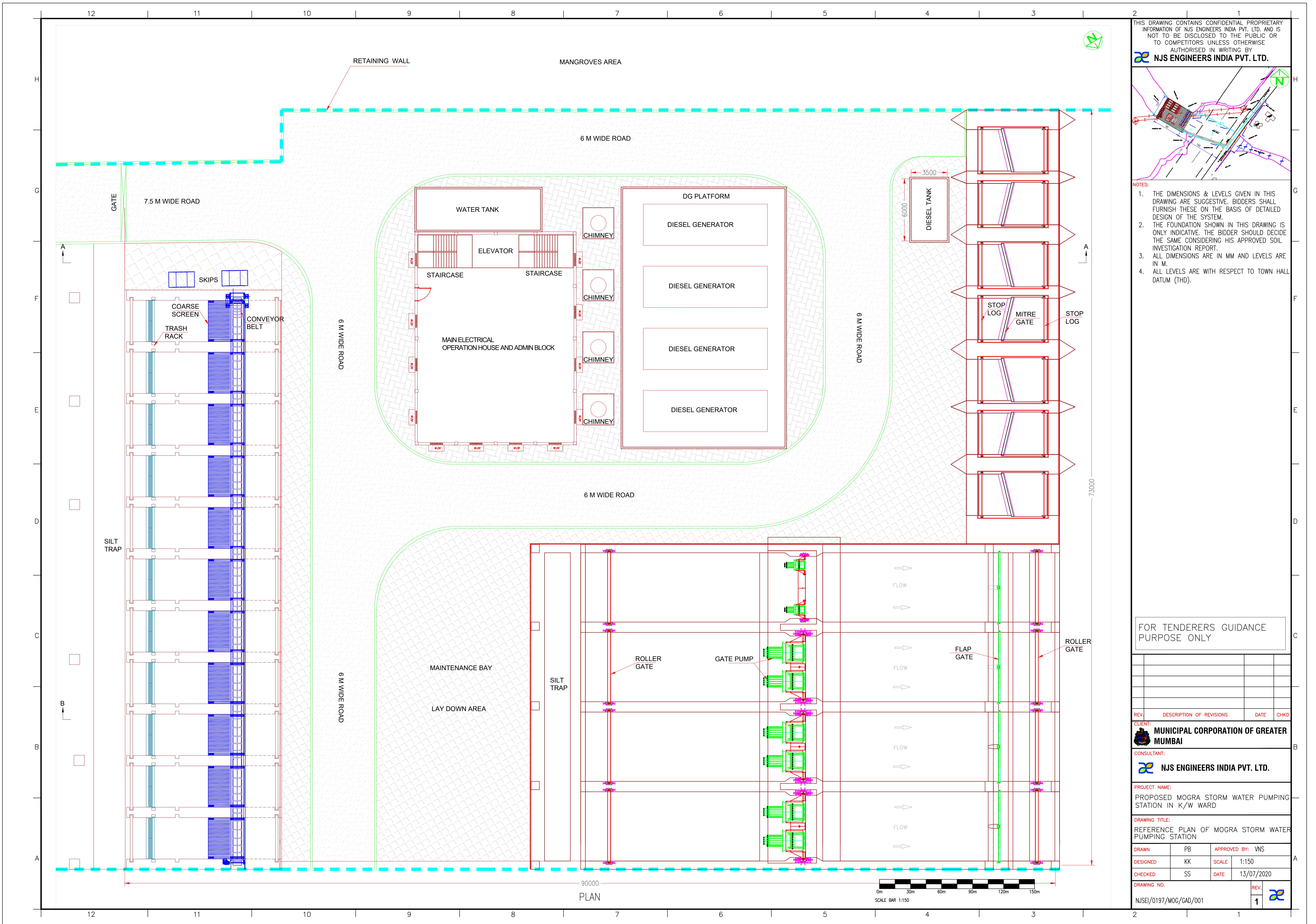
Sr. No.	Description	Unit	Particulars
4.1.41 (a)	AC distribution board for Instrumentation & Control and Telemetry System Make and Model		
(b) (c)	Pre-fabricated		
	Country of Origin		
(l)	ORP Measurement system Make and model Technical Details Country of Origin		
(m)	Auto samplers Make and model Technical Details Country of Origin		
4.1.45	CCTV SURVEILLANCE SYSTEMS: Make: Model: Country of Origin: TECHNICAL DETAILS:		

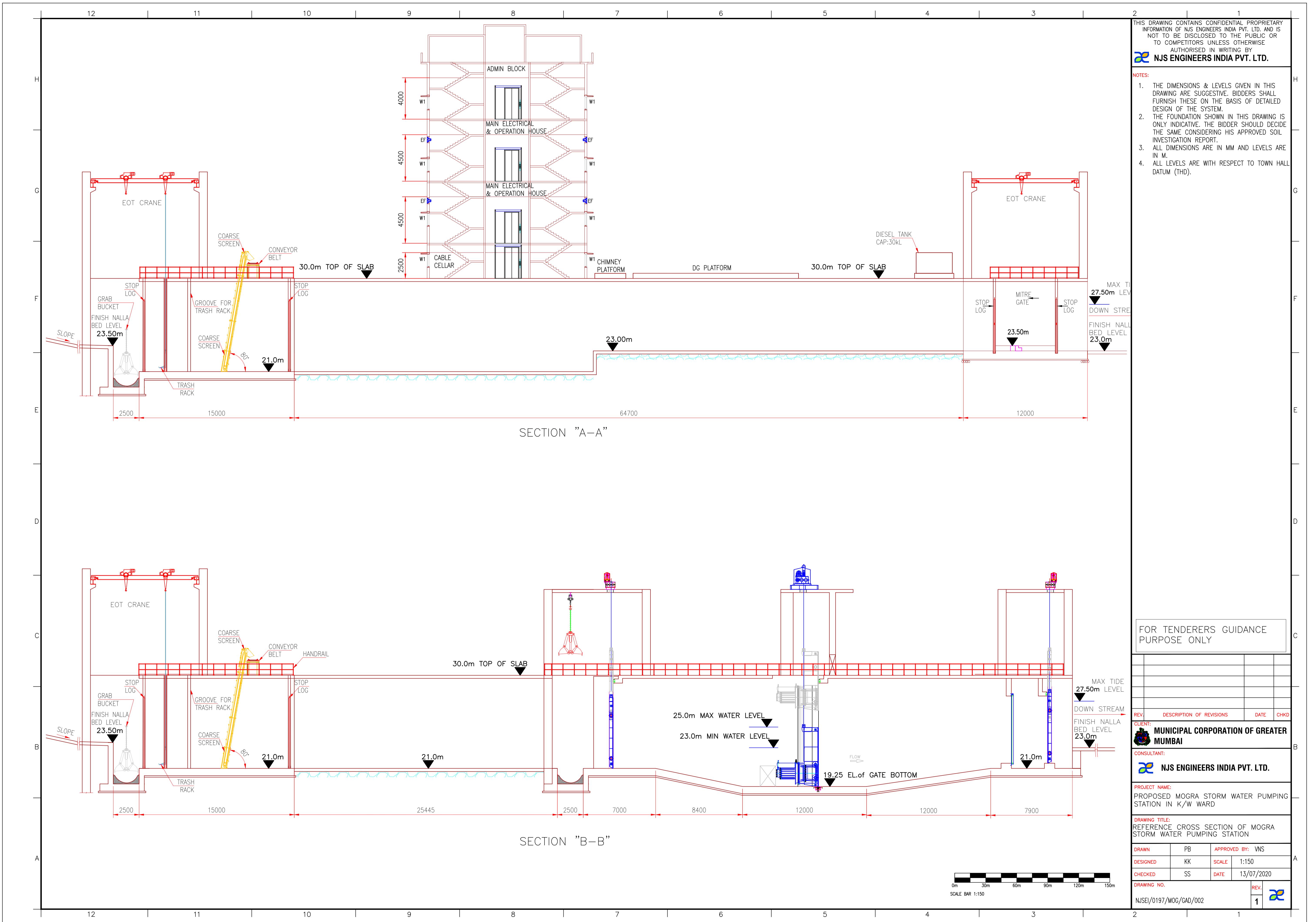
Section 2H

Drawings

NOTES:
 1. HIGH TENSION ELECTRICAL LINE SHALL
BE REROUTED AWAY FROM PROPOSED
STORM WATER PUMPING STATION.
 2. ALL RAILINGS SHALL BE 1.2m HIGH, 2
LEVEL WITH TOE GUARD.
 3. MANGROVES SHALL NOT BE DISTURBED
DURING EXECUTION OF WORK.
 4. ALL INTERNAL ROADS, SHALL BE 6m
CLEAR WIDTH TO BE PROVIDED WITH
CRASH BARRIER.







LEGEND:

6.6 kV VCB/SF6 CIRCUIT BREAKER, MOTORISED, DRAWS OUT

MOULDED CASE CIRCUIT BREAKER WITH THERMAL (O/L) & MAGNETIC (S/C) RELEASE

MULTI-FUNCTION

- PHASE CURRENTS.
- LINE VOLTAGES.
- FREQUENCY.
- KW, KVA, KVAR WITH MAXIMUM DEMAND FOR KVA.
- P.F.
- KWH

51 IDMT PHASE OVERCURRENT PROTECTION

50 HIGHSET INSTANTANEOUS PHASE OVERCURRENT PROTECTION

50H INSTANTANEOUS EARTH OVERCURRENT PROTECTION

51N IDMT EARTH OVERCURRENT PROTECTION

64R RESTRICTED EARTH FAULT PROTECTION

51G IDMT NEUTRAL OVERCURRENT PROTECTION (STANDBY E/F)

86 LOCKOUT RELAY

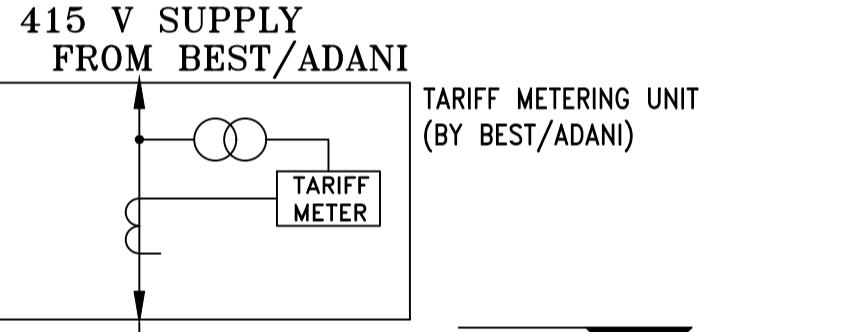
TCS TRIP CIRCUIT SUPERVISION RELAY

CURRENT TRANSFORMER.

CORE BALANCE C.T.

MPR

- SHORT CIRCUIT PROTECTION
- THERMAL OVERLOAD PROTECTION
- STALLED ROTOR PROTECTION
- NEGATIVE PHASE SEQUENCE CURRENT PROTECTION
- EARTH FAULT PROTECTION
- PROTECTION AGAINST REPEATED START
- WINDING AND BEARING OVER-TEMPERATURE PROTECTION



FOR TENDER PURPOSES ONLY
NOT TO BE USED FOR CONSTRUCTION

1 CHANGE IN RATINGS, CAPACITIES & QUANTITIES, 16/03/20

REV. DESCRIPTION OF REVISIONS DATE CHKD

CLIENT: MUNICIPAL CORPORATION OF GREATER MUMBAI

CONSULTANT: NJS ENGINEERS INDIA PVT. LTD.

PROJECT NAME: PROPOSED MOGRA STORM WATER PUMPING STATION IN K/W WARD

DRAWING TITLE: REFERENCE SINGLE LINE DIAGRAM FOR POWER DISTRIBUTION SYSTEM

DRAWN PB APPROVED BY: VNS

DESIGNED KK SCALE NTS

CHECKED SS DATE 13/07/2020

DRAWING NO. REV.

NJSEI/0197/MOG/SLD/004

NOTES:

1. CONTROL VOLTAGE FOR 6.6 kV VCBs/SF6 CBs, SOFT STARTERS SHALL BE 110 V DC.
2. CONTROL VOLTAGE FOR MOTOR STARTERS SHALL BE 110 V AC AND THE SAME SHALL BE DERIVED WITH A 415/110 V CONTROL TRANSFORMER OF ADEQUATE KVA RATING. 1 no. TRANSFORMER SHALL BE PROVIDED FOR EACH BUS.
3. 15% SPARE FEEDERS, SUBJECT TO A MINIMUM OF 1 no., OF EACH TYPE & RATING SHALL BE PROVIDED ON EACH BUS.
4. ALL 6.6 KV BREAKERS, METERS etc. SHALL BE SUITABLE FOR INTERFACE WITH PLC/SCADA SYSTEM.
5. DG SET PROTECTIONS SHALL BE FOLLOWING MINIMUM:
 - a) PHASE OVERCURRENT (VOLTAGE CONTROLLED) & EARTH FAULT OVERCURRENT
 - b) GROUND OVERCURRENT - STANDBY EARTH FAULT
 - c) OVERVOLTAGE & UNDERVOLTAGE
 - d) OVERFREQUENCY (OVERSPEEDING) & UNDERFREQUENCY WITH df/dt FEATURE
 - e) LOSS OF EXCITATION
 - f) ANTI-MOTORING (LOSS OF PRIME MOVER) - REVERSE POWER
 - g) NEGATIVE PHASE SEQUENCE OVERCURRENT
 - h) WINDING AND BEARING OVER-TEMPERATURE
 - i) RESTRICTED EARTH FAULT - INSTANTANEOUS TYPE

* - RATINGS TO BE DECIDED BY THE CONTRACTOR AND SUBJECT TO APPROVAL BY THE ENGINEER.

